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BIG CREEK FLOOD CONTROL PROJECT, CLEVELAND, OHIO. PHASE II. GEN--ETC(U)
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BIG CREEK FLOOD CONTROL PROJECT

CLEVELAND, OHIO

PHASE II
GENERAL DESIGN MEMORANDUM

APPENDIX D
DESIGN ANALYSIS

Prepared by
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For
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AUGUST 1979

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A102 433	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Big Creek Flood Control Project, Cleveland, Ohio. Phase II. General Design Memorandum. Appendix D. Design Analysis.		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, Buffalo 1776 Niagara Street Bufalo, New YOrk 14207		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer District, Buffalo 1776 Niagara Street Buffalo, New YOrk 14207		12. REPORT DATE 1979
		13. NUMBER OF PAGES 168
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 12 377		15. SECURITY CLASS. (of this report)
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Flood Control
Big Creek

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of this appendix is to present the design criteria procedures, and calculations associated with the design of the principal features of the Big Creek Flood Control Project. Preequissites to this appendix are appendix A: Soil, Geology, and Construction Materials; Appendix B; Alternative Studies; and Appendix C: Hydrology and Hydraulics. The results of the subsurface exploration program presented in Appendix A, established the general adequacy of the site for the flood control project. The field and laboratory testing

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program determined the variousengineering properties of the project soils and borrow material required for the design analysis. In appendix B, various alternatives for the principal features of the project were studies, and an alternative was selected for final design. The water surface profile presented in Appendix C was used for setting the tops of the various containment structures, and the channel velocities presented in Appendix C were used for sizing riprap and gabron protection.

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BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

PHASE II
GENERAL DESIGN MEMORANDUM

APPENDIX D

DESIGN ANALYSIS

SECTION A

INTRODUCTION

D1. Purpose. The purpose of this Appendix is to present the design criteria, procedures, and calculations associated with the design of the principal features of the Big Creek Flood Control Project.

D2. Previous Studies. Prerequisites to this Appendix are Appendix A: Soil, Geology, and Construction Materials; Appendix B: Alternative studies; and Appendix C: Hydrology and Hydraulics. The results of the subsurface exploration program, presented in Appendix A, established the general adequacy of the site for the flood control project. The field and laboratory testing program determined the various engineering properties of the project soils and borrow material required for the design analysis. In Appendix B, various alternatives for the principal features of the project were studied, and an alternative was selected for final design. The water surface profile presented in Appendix C was used for setting the tops of the various containment structures, and the channel velocities presented in Appendix C were used for sizing riprap and gabion protection.

SECTION B

STRUCTURAL DESIGN

D3. General. This Section presents the basic data, design criteria, assumptions and loading conditions used in designing the various structures of the Big Creek Flood Control Project. Design computations for the hydraulic structures are presented in Subappendix D1. Design computations for the relocated Baltimore and Ohio Railroad mainline bridge, the Baltimore and Ohio Railroad spurline bridge, and the temporary trestle for the Norfolk and Western Railroad are presented in Subappendix D2.

D4. Design Criteria. Design stresses, design criteria, loading conditions, assumptions and methods were based on applicable Corps of Engineers' engineering and design manuals or on industry codes, supplemented where necessary by conservative judgment and experience. Publications used in establishing design criteria include the following:

Manuals - Corps of Engineers

(1) EM 1110-2-2000, 1 November 1971, "Standard Practice of Concrete".
(2) EM 1110-2-2101, 1 November 1963, "Working Stress for Structural Design".
(3) EM 1110-2-2103, 21 May 1971, "Details of Reinforcement-Hydraulic Structures".
(4) EM 1110-2-2400, 2 November 1964, "Structural Design of Spillway and Outlet Works".
(5) EM 1110-2-2501, 18 June 1962, "Floodwalls".
(6) EM 1110-2-2502, 29 May 1961, "Retaining Walls".

Engineering Technical Letters-Corps of Engineers

(1) ETL 1110-2-184, 25 February 1974, "Gravity Dam Design-Stability".
(2) ETL 1110-2-236, 30 June 1978, "Design Criteria-Paved Concrete Flood Control Channels".

Other Publications

(1) ACI Building Code (ACI 318-77).
(2) ACI Design Handbook (ACI SP-3).
(3) ACI Design Handbook (ACI SP-17-73).
(4) AISC Manual of Steel Construction, 1970, with supplement dated September 1978.
(5) Manual for Railway Engineering, American Railway Engineering Association, 1975.
(6) Stresses in Framed Structures, Hool and Kinne, 1942, McGraw Hill.
(7) Standard Specifications for Highway Bridges, American Association of State Highway and Transportation Officials, 1977 and 1978 Interim.
(8) Structural Welding Code, D1.1-75 including Revision 1-76 and Revision 2-77, American Welding Society.

D5. Concrete. The reinforced concrete hydraulic structures were designed with working stresses given in the ACI Building Code and based on an ultimate compressive strength (f'_c) of 3,000 psi at 28 days. Working stress modifications for hydraulic structures are in accordance with EM 1110-2-2101. Reinforced concrete railroad structures were designed with working stresses given in the AREA Manual and based on an ultimate compressive strength (f'_c) of 3,000 psi at 28 days.

D6. Concrete Working Stresses. The following table lists the concrete and reinforced concrete working stresses used in design.

Concrete Working Stresses
Hydraulic Structures

	Working Stress (psi)
Compressive Stress (f'_c)	
f'_c = 3,000 psi	
Flexure (f_c)	
Extreme fiber stress in compression, $0.35\, f'_c$	1,050
Extreme fiber stress in tension (plain concrete for footings, walls, and on downstream toe of spillway weir, but not for other portions of gravity sections) $1.2\sqrt{f'_c}$	66
Extreme fiber stress in tension (for other portions of gravity sections, where permitted by pertinent engineering manual) $0.6\sqrt{f'_c}$	33
Shear (v) (As a measure of diagonal tension at a distance "d" from the face of the support).	
Beams with no web reinforcement, $1.1\sqrt{f'_c}$	60
Members with vertical or inclined web reinforcement or properly combined bent bars and vertical stirrups, $5.5\sqrt{f'_c}$	300
Slabs and footings, $2\sqrt{f'_c}$	110
Bond (u)	
With "D" equal to the nominal bar diameter in inches, the bond stress shall not exceed the following:	
For tension bars with size and deformation conforming to ASTM A 615, A 617:	

Top Bars ________________ $\frac{3.4\sqrt{f'_c}}{D}$, 350 Max.

Bars other than top bars ________ $\frac{4.8\sqrt{f'_c}}{D}$, 500 Max.

Bearing (f_c)

On full area, 0.25 f'_c ________________ 750

On one-third area or less, 0.375 f'_c ________ 1,125

When the loaded area is greater than one-third but less than the full area, the bearing stress will be interpolated between the values given.

Modular Ratio (n)

n = 9.2

Concrete Working Stresses
Railroad Structures
(AREA)

Working Stress (psi)

Compressive Stress (f'_c)

f'_c = 3,000 psi

Flexure (f_c)

Extreme fiber stress in compression,
0.45 f'_c ________________ 1,350

Shear (v) (As a measure of diagonal tension at a distance "d" from the face of the support).

Slabs and footings (peripheral shear, Sec. F, Art. 8) $2\sqrt{f'_c}$ ________ 110

Bond (u)

(1) Tension bars No. 3 - No. 11 with deformations conforming to ASTM A 615, A 617 ("D" is the nominal diameter of bar, inches):

Top Bars ________________ $\frac{3.4\sqrt{f'_c}}{D}$, 350 Max.

Top bars in reference to bond are horizontal bars so placed that more than 12 inches of concrete is cast in the member below the bar.

Bars other than top bars $\frac{4.8\sqrt{f'_c}}{D}$, 500 Max.

(2) All compression bars with deformations conforming to ASTM A 615, A 617 ______ $\frac{6.5\sqrt{f'_c}}{D}$, 400 Max.

Bearing (f_c)

Full area loaded, 0.25 f'_c ______ 750

Modular Ratio (n)

The ratio of the modulus of elasticity of steel to that of concrete, Es/Ec, equals "n" and shall be based upon the compressive strength of the concrete as follows:

For f'_c (psi) between 3,000 and 3,999 ______ n = 10

D7. Reinforcing Steel. All reinforcing steel bars for both the hydraulic structures and the railroad structures were designed for the working stresses of new billet steel, intermediate grade, deformed bars conforming to ASTM A 615 or A 617, Grade 40. Working stresses for hydraulic structures are in accordance with the requirements of the ACI Building Code, except as modified in EM 1110-2-2101. The flexural (f_s) working stress, with or without axial loads, is 20,000 psi for both the hydraulic structures and the railroad structures.

D8. Minimum embedment lengths and splice lengths for the hydraulic structures conform to ACI 318-77 and EM 1110-2-2103. Minimum embedment lengths and splice lengths for the railroad structures conform to the AREA Manual. Splices at points of maximum moments were avoided and, where possible, were staggered in adjacent bars. When the structural analysis indicated that bending and direct stress exists under the critical loading, reinforcing steel, if required, was computed for both bending moment and axial load.

D9. Temperature and shrinkage reinforcement for the hydraulic structures was in accordance with the applicable requirements of ACI 318-77, EM 1110-2-2103, and EM 1110-2-2400. Temperature and shrinkage reinforcement for the railroad structures was in accordance with the AREA Manual.

D10. Structural Steel. Structural steel was designed for ASTM A36, Fy = 36,000 psi. Bolted connections were designed for ASTM A325, H.S. Bolts.

D11. Basic Data and Assumptions. The following basic data and assumptions were used in design of the hydraulic structures:

(1) Dead loads (pounds per cubic foot).

compacted backfill, saturated	125
compacted backfill, moist	125
compacted backfill, submerged	62.5
concrete, plain and reinforced	150

(2) Live loads.

water (pounds per cubic foot) ______________ 62.5

wind (pounds per square foot) ______________ 30.0

live load surcharge - equivalent to 2 feet of soil

(3) Water pressure.

Hydrostatic pressure as in submerged fill and free water, were applied to structures by conventional pressure distribution. Uplift pressures are treated in subsequent paragraphs where loading conditions are given.

(4) Earth pressures.

Vertical earth loads were given unit weight in accordance with assigned loading conditions. In general, lateral earth pressures were determined in accordance with Corps of Engineers' manual EM 1110-2-2502.

(5) Frost protection.

A minimum protective earth cover of 4 feet was used for frost protection.

D12. Joints in Concrete Construction. Joints in concrete construction will be provided as follows:

(1) Horizontal and vertical contraction joints.

The concrete elements of the various structures will be separated by contraction joints to relieve restraint and minimize the development of cracks. Reinforcement will not extend across the joints, and concrete bond will be broken by the application of a bituminous coating. Rubber or polyvinyl-chloride waterstops will be used in contraction joints to prevent water flow and subsequent damage. For concrete structures that function similar to floodwalls and have a design water surface that is higher than the adjacent existing ground surface, waterstops will be used in horizontal and vertical contraction joints to prevent water flow from the channel side to the land side of the structure. For concrete structures that will act solely as retaining structures, waterstops will be used in vertical contraction joints to prevent piping of backfill material through the contraction joints. Waterstops will not be used in horizontal contraction joints of concrete structures founded on rock.

(2) Horizontal and vertical construction joints.

These joints will be located to facilitate construction procedure and minimize shrinkage cracks. The reinforcement will be continuous through the construction joint.

(3) Expansion joints.

Expansion joints will be provided for volume change of the concrete, prevention of spalling, and prevention of

serious effects from cracking. A premolded 1/2-inch joint filler will be installed in the joints.

D13. Railroad Bridges and Temporary Trestle. The Baltimore and Ohio Railroad mainline and spurline bridges and the temporary trestle for the Norfolk and Western Railroad were designed in accordance with the American Railway Engineering Association (AREA) Manual for Railway Engineering, Chapter 8 - Concrete Structures and Foundations and Chapter 15 - Steel Structures.

D14. The superstructures were designed for loads and forces as shown in AREA Chapter 15 with recommended live load Cooper E80 with diesel impact. AREA recommends Cooper E80 loading for steel structures (Page 15-1-6). Structural steel was designed for ASTM A36, Fy 36,000 psi. Bolted connections were designed for ASTM A325, H.S. Bolts. Fatigue design was in accordance with American Welding Society (AWS) Structural Welding Code D1.1, Revision 2-77. All welding was designed in accordance with AREA and AWS criteria.

D15. The substructures were designed for loads and forces as shown in AREA Chapter 8 with recommended live load Cooper E72 without impact. AREA recommends Cooper E72 loading for concrete structures (Page 8-2-3). Ice and stream flow loads were in accordance with the American Association of State Highway and Transportation Officials Standard Specifications for Highway Bridges, 1978 Interim. Abutments and wings were designed as semi-gravity type founded on rock with an allowable foundation pressure of 10 kips per square foot. Structural backfill shall be AREA Type 1 granular backfill.

D16. The temporary trestle was designed for the same loads and forces as the superstructures. Structural steel, bolted connections, and welding design were the same as for the superstructures. Piles were designed for HP12 x 74, ASTM A36, with maximum allowable design pile load equal to 100 tons based on 9,000 psi point pressure.

D17. Concrete Chute-Transition At Upstream End of Project. The chute-transition at the upstream end of the project was designed as two reinforced concrete L-walls with a reinforced concrete slab between. The same design was used for both the section of the zoo access road immediately adjacent to the chute-transition and for the section of road leading to the Brookside Park Drive underpass that is immediately adjacent to the chute-transition. Reinforced concrete keys will be provided at both the upstream and downstream ends of the chute-transition. There is no specific design requirement for these keys; however, based on engineering judgment it is felt that for a hydraulic structure of this type keys are desirable. The key at the upstream end of the structure will reduce underseepage, and it will lessen the possibility of undermining of the slab if erosion of the upstream soil occurs. The key at the downstream end of the structure will reduce underseepage, and it will help in preventing the underdrainage system from being overtaxed. A drainage system will be provided behind the walls, and a subdrainage system will be provided for the slabs. Design computations are presented in Subappendix D1.

D18. The L-walls were designed as retaining walls except for about a 50-foot reach at the right bank near the downstream end of the two-barrel conduit. Along this reach, the chute-transition will be close to the end of the two-barrel conduit, and the amount of backfill that can be placed is limited. The lowest point of the top of backfill is at about the chute-transition grade. This reach of wall was designed as a floodwall. The sudden drawdown condition was used for the retaining wall design. The design flood condition was used for the floodwall design. Loading conditions are as follows:

Case I - Sudden Drawdown Condition

(a) Chute-transition empty.
(b) Backfill at maximum elevation (6 inches below top of wall).
(c) Backfill submerged to an elevation midway between the design water surface and bottom of slab (corresponds to the assumption of a 50 percent effective wall drainage system).
(d) Backfill above the level of submergence naturally drained.
(e) Lateral earth pressure from backfill based on an active pressure coefficient (Ka = 0.33).
(f) Uplift across the base varies uniformly from reduced hydrostatic head at heel to 3-foot hydrostatic head at inside face of wall. Uniform 3-foot hydrostatic head from inside face of wall to toe of wall.

Case II - Design Flood Condition.

(a) Water surface at design elevation.
(b) Backfill at minimum elevation.
(c) Backfill naturally drained.
(d) Uplift varying uniformly across the base.

D19. Stability criteria for the L-walls is as follows:

(1) Resultant shall be within the middle third of the base.
(2) Sliding Factor $\Sigma H/\Sigma V$ shall not exceed 0.60.
(3) Maximum foundation pressure shall not exceed 2 kips per square foot.

D20. The slab between the walls was designed with consideration given to its dual purpose. It will be used as both a floodway channel and a roadway. Although a subdrainage system will be provided, it is not assumed to be 100 percent effective. The slab at the downstream end of the chute-transition will have a zero percent slope. A head will have to develop in the subdrainage system in order to drain subsurface water. The slab was designed to resist a uniform uplift equal to a 3-foot hydrostatic head. The slab design and subdrainage system is presented in Subappendix D1.

D21. Concrete Transition at End of Three-Barrel Conduit. The transition at the end of the three-barrel conduit was designed as two reinforced concrete L-walls with a reinforced concrete slab between. The upstream end

of the transition will tie into the existing slab and wingwalls. A reinforced concrete key will be provided at the downstream end of the transition. A drainage system will be provided behind the walls; and weep holes, drilled 10 feet into rock, will be provided in the bases of the L-walls and in the middle slab. The drainage system is needed to reduce hydrostatic pressures that are expected to develop from the sudden drawdown condition. The 10-foot depth of the weep holes is based on engineering judgment. For similar hydraulic structures on other projects, this depth has been used for weep holes in rock. Design computations are presented in Subappendix D1.

D22. The L-shaped walls were designed for the sudden drawdown condition. Loading conditions are as follows:

<u>Sudden Drawdown Condition.</u>

(a) Water in the transition at channel grade.
(b) Backfill 6 inches below top of wall.
(c) Backfill submerged to an elevation midway between the design water surface and channel grade (corresponds to the assumption of a 50 percent effective drainage system).
(d) Backfill above the level of submergence naturally drained.
(e) Lateral earth pressure from backfill based on an attest pressure coefficient (Kr = 0.60).
(f) Uplift uniform across the base (pressure equal to reduced hydrostatic head in backfill).

D23. Since the L-walls will be founded on rock, an at-rest earth pressure coefficient was used. In accordance with EM 1110-2-2502, Paragraph 4e, when using at-rest pressures, resultants located outside the middle third are acceptable, provided that maximum foundation pressures are within safe values. The stability criteria is as follows:

(1) Resultant shall be within the middle half of the base.
(2) Shear-friction factor of safety shall not be less than 4.
(3) Maximum foundation pressure shall not exceed 10 kips per square foot.

D24. The slab between the L-walls was designed to resist a uniform uplift based on the head from the sudden drawdown condition. This corresponds to the assumption of a 50 percent effective drainage system. Anchor bars will be provided as required to ensure stability of the slab.

D25. <u>Concrete Flume and Retaining Walls at West 25th Street Bridge.</u> The flume at the upstream end of the diversion channel was designed as a reinforced concrete U-frame. A reinforced concrete key will be provided at the downstream end of the flume. A drainage system will be provided behind the walls; and weep holes, drilled 10 feet into rock, will be provided in the slab. The right side of the flume that is adjacent to the West 25th Street bridge pier will require a special bracing system to resist surcharge loading from the bridge pier. The bracing system will consist of pre-cast

reinforced concrete lagging, vertical structural steel beams, and structural steel struts. The bracing system will become an integral part of flume. The flume was checked for stability against flotation, and it was found to be adequate. Design computations are presented in Subappendix D1.

D26. The flume was designed for the following loading condition:

Sudden Drawdown Condition

(a) Flume empty.
(b) Backfill 6 inches below top of wall.
(c) Backfill submerged to elevation midway between the design water surface and flume grade (corresponding to the assumption of 50 percent effective drainage system).
(d) Backfill above level of submergence naturally drained.
(e) Lateral earth pressure from backfill based on an at-rest pressure coefficient (Kr = 0.60).
(f) Uniform uplift across the base (pressure equal to the reduced head in the backfill).
(g) Surcharge loading from Bridge Pier No. 14 where required.

D27. At the upstream end of the flume, the wingwalls at the right bank and the wall between the flume and the new Baltimore and Ohio Railroad mainline bridge abutment were designed as reinforced concrete T-walls. Reinforced concrete keys will be provided at the toes of the walls. A drainage system will be provided behind the walls. Design computations are presented in Subappendix D1.

D28. The T-walls were designed for the following loading condition:

Sudden Drawdown Condition

(a) Channel empty.
(b) Backfill 6 inches below top of wall.
(c) Backfill submerged to elevation midway between the design water surface and the channel grade (corresponding to the assumption of 50 percent effective drainage system).
(d) Backfill above level of submergence naturally drained.
(e) Lateral earth pressure from backfill based on an at-rest pressure coefficient (Kr = 0.60).
(f) Uniform uplift across the base (pressure equal to the reduced hydrostatic head in the backfill).

D29. Since the T-walls will be founded on rock, an at-rest earth pressure coefficient was used. Stability criteria is the same as outlined in Paragraph D23.

D29a. Foundation Conditions for Concrete Structures. Project soils consist principally of sandy, silty clay. Bedrock at the project site is predominately gray shale that is horizontally bedded. A detailed discussion on the soils and geology at the project site and the results of the subsurface exploration and testing programs are presented in Appendix A. Except

for the chute-transition at the upstream end of the project, all concrete structures will be founded on rock. As discussed in Appendix A, the shale has the characteristic of air-slaking. For the concrete structures founded on rock, the concrete will have to be placed on the foundation immediately after excavating to final grade, or the foundation surface will have to be protected, such as being kept continuously wet.

D29b. The chute-transition will be founded on natural overburden material consisting principally of sandy, silty clay, classified as CL. Based on computations presented in Subappendix D1, an allowable foundation pressure of 2.0 kips per square foot was selected for the soil foundation. The two-barrel conduit is located beneath a portion of the chute-transition. Care will have to be exercised during construction so as not to damage this conduit. Some dewatering is anticipated during construction at the downstream end of the chute-transition.

D29c. The concrete transition at the end of the three-barrel conduit will be founded on a gray, silty shale. Core borings indicate that the foundation is adequate for the structure. For design, the maximum allowable foundation pressure was set at 10 kips per square foot. As the structure will be constructed in existing Big Creek, diversion and dewatering will be required during construction.

D29d. The flume at the upstream end of the diversion channel and the associated walls at the upstream end of the flume will be founded on a gray shale. Core borings indicate that the foundation is adequate for these concrete structures. The maximum allowable foundation pressure was set at 10 kips per square foot for design. As the flume will be located between the existing piers of the West 25th Street bridge, care will have to be exercised during construction in order not to damage the existing piers. It is anticipated that some dewatering will be required during construction.

D29e. The two abutments of the Baltimore and Ohio Railroad mainline bridge and the two abutments and pier of the Baltimore and Ohio Railroad spurline bridge will be founded on a gray, silty shale. Bottoms of footings will be placed in the shale and a value of 10 kips per square foot was assigned for maximum allowable foundation pressure. As the concrete structures will be constructed in existing Big Creek, diversion and dewatering will be required during construction.

SECTION C

RIPRAP AND GABION DESIGN

D30. General. This Section presents the basic data, design criteria, and assumptions used in designing the channel bottom and side slope protection for the Big Creek Flood Control Project. Also included in this Section is the design of the protection required for the drop structures.

D31. Design Criteria. Design criteria, assumptions, and methods were based on applicable Corps of Engineers' engineering and design manuals, supplemented where necessary by conservative judgment and experience. Publications used in establishing design criteria include the following:

Manual - Corps of Engineers

(1) EM 1110-2-1601, "Hydraulic Design of Flood Control Channels", 1 July 1970

Engineering Technical Letter - Corps of Engineers

(1) ETL 1110-2-120, "Additional Guidance for Riprap Channel Protection", 14 May 1971

Other Publication

(1) Technical Report H-75-19, Fourmile Run Local Flood-Control Project, Alexandria and Arlington County, Virginia, Hydraulic Model Investigation, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi 39180, December 1975

D32. Riprap Design. The riprap was designed in accordance with the method presented in EM 1110-2-1601 and ETL 1110-2-120. Average channel velocities were used to determine riprap size. Where the channel is curved, a bend-loss factor(BLF) was computed by the following formula from EM 1110-2-1601, Plate 34:

$$BLF = 3.10 \left(\frac{W}{R}\right) 0.5$$

R = Centerline radius of channel curve in feet.
W = Top width of channel in feet, computed by projecting the channel sideslopes to design water surface.

A nonuniform flow factor of 1.5 was used. If the BLF exceeded the nonuniform flow factor, the BLF was used in lieu of the nonuniform flow factor. Computations for riprap design are presented in Subappendix D3. The

gradation of 12-inch thick riprap and 18-inch thick riprap is presented in Appendix A.

D33. Gabion Design. As an alternative to the use of riprap, the use of gabions was considered in Appendix B, Alternative Studies. The results of the Alternative Studies showed that gabions are less expensive than riprap where required riprap protection is 24-inch thick or greater. The required gabion thickness is set equal to one-half the required riprap thickness. As discussed in Appendix B, this gabion-riprap relationship was established from model tests for the Fourmile Run Local Flood-Control Project.

> Technical Report H-75-19, Fourmile Run Local Flood-Control Project, Alexandria and Arlington County, Virginia, Hydraulic Model Investigation, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi 39180, December 1975.

If 24-inch thick riprap is required, then only a 12-inch thick gabion would be required. The gradation of stone used to fill gabion baskets is presented in Appendix A.

D34. Freeboard. The top of riprap and gabion protection was set 3.0 feet vertically above design water surface on the levee slope and 2.5 feet on all other channel slopes.

D35. Bedding Material. A 6-inch thick layer of bedding material will be provided beneath both riprap protection and gabion protection. The use of filter cloth in lieu of using bedding material was considered in Appendix B. However, the filter cloth was found not to be feasible for the project site. The gradation of the bedding material is presented in Appendix A.

D36. Protection of Air-Slaking Shale. The shale at the project site has the characteristic of air-slaking. The need to protect the air-slaking shale is discussed in Appendix A. Various alternatives for protecting the air-slaking shale were considered in Appendix B. Where the channel bottom is in bedrock and not continuously wet, riprap protection will be provided on the channel bottom where channel velocities are high.

D37. Summary of Riprap and Gabion Design. The riprap and gabion design resulted in the following:

Station	Area	Protection	Remarks
	Diversion Channel		
67+ 74D- 61+00D	Banks and Bottom	12" Riprap	Diversion Channel
61+ 00D- 58+00D	Banks and Bottom	18" Riprap	Downstream end of diversion channel

Station	Area	Protection	Remarks
		Floodway.	
112+ 80F-111+80F	Banks and Bottom	12" Riprap	Downstream end of concrete chute
110+ 20F-109+50F	Banks and Bottom	12" Gabions	Drop Structure No. 1
105+ 20F-104+50F	Banks and Bottom	12" Gabions	Drop Structure No. 2
100+ 20F- 99+50F	Banks and Bottom	12" Gabions	Drop Structure No. 3
95+ 20F- 94+50F	Banks and Bottom	12" Gabions	Drop Structure No. 4
92+ 00F- 91+30F	Banks and Bottom	12" Gabions	Drop Structure No. 5
		Modified Channel.	
115+22.5M-114+50M	Bottom	12" Riprap	Downstream of 2-barrel conduit
89+ 50M- 89+00M	Banks and Bottom	12" Gabions	Downstream of 3-barrel conduit
89+ 00M- 87+65M	Left Bank	12" Gabions	Confluence Area
89+ 00M- 87+00M	Right Bank	12" Gabions	Confluence Area
76+ 00M- 74+00M	Banks and Bottom*	12" Riprap	R.R. spur bridge
70+ 52D- 69+74D	Right Bank	12" Riprap	Approach to flume
71+ 00M- 70+00M	Left Bank	12" Riprap	Mainline B&O R.R. bridge

*except low flow channel.

D38. Discussion on Design. In general, the riprap and gabion design was in accordance with the methods noted. However, a certain amount of engineering judgment entered into the design where the hydraulic performance was uncertain. In areas of uncertain hydraulic performance, a conservative approach was taken in selecting the thicknesses of riprap and gabions and in determining the lengths of reaches requiring protection.

D39. In the floodway channel, except at the drop structures, the channel velocities vary between 5.4 and 6.3 feet per second (fps). Paragraph 13c of EM 1110-2-1601 recommends a maximum mean velocity in Bermuda grass-lined channels of 6.0 fps for sandy silt and 8.0 fps for silt clay. Although the maximum mean channel velocities are slightly above the recommended maximum, it is not felt that the deviations are sufficiently significant to warrant the expense of riprap protection. Furthermore, the channel will be dry most of the time; the floodway only carries flood discharge. This will provide good conditions for establishing and maintaining a good grass cover.

D40. At the downstream end of the concrete transition located at the downstream end of three-barrel conduit, the modified channel is narrow. Average channel velocities are high, and the centerline curves are relatively sharp. The left bank of the modified channel will be overtopped during the design flood by flows in the floodway channel. Twelve-inch thick gabions (24-inch riprap) was the computed requirement just downstream of the concrete transition. These gabions were extended to cover the nose where the floodway channel joins the modified channel. Although the 12-inch gabions selected will provide more protection than computations show are needed, the computations do not include the effects of the expected turbulence and eddies at the confluence. Because of the overtopping, the flow in this reach of the diversion channel may be greater than the discharges used in design. The riprap on the right bank of the modified channel was extended downstream until it was felt that the flows between the floodway channel and the modified channel would be fully combined.

D41. Along all of the diversion channel, the computed riprap thickness is 12 inches. At the downstream end, an 18-inch thickness is selected. This is a confluence area with flows joining at right angles. Turbulence and eddies can be expected. The conservative design is therefore believed to be warranted. The need for keys in riprap revetment is outlined in Paragraph 14K of EM 1110-2-1601. It is stated in this paragraph that "the upstream and downstream ends of riprap revetment should be protected against erosion by increasing the revetment thickness or extending the revetment to areas of noneroding velocities". Although this reference pertains to riprap revetment, it is believed to be equally applicable for gabion structures. Where riprap and gabions terminate, a change in roughness occurs and increased turbulence can be expected. Because of the increased turbulence, the erosion potential is greater; and, therefore, there is need for additional protection. Keys are, therefore, used along the edges of the riprap or gabions where they terminate. The key detail is a 3-foot by 3-foot gabion placed in a trench. Although this detail is not one of the standard riprap key details shown in EM 1110-2-1601, it has been used on Corps of Engineer Flood Control Projects. It is felt that gabion keys provide better protection than riprap keys because they extend further below the channel template than the standard keys and because they are firmly connected together.

SECTION D

SLOPE STABILITY ANALYSES

D42. General. A detailed discussion on the soils and geology at the project site is presented in Appendix A. Adopted design values for the project soils for the slope stability analyses are presented in Appendix A. The adopted design values include both shear strength parameters and the unit weights of soils involved.

D43. It is anticipated that the majority of fill used for constructing the embankment of the relocated Baltimore and Ohio Railroad mainline will come from an offsite borrow area. However, the results of the exploration and testing program for the offsite borrow area were not available at the time the slope stability analyses had to be run. In order not to delay the schedule for completion of the design of the project, it was assumed that the shear strength of the borrow material would be equal to or greater than the shear strengths of the project soils. This decision was made by the Buffalo District, Corps of Engineers during a meeting with Gannett Fleming Corddry and Carpenter, Inc., on December 14, 1978. The validity of this assumption will have to be checked when the results of the exploration and testing program for the offsite borrow area are available.

D44. References. Publications used in establishing design criteria and procedures include the following:

Manuals - Corps of Engineers

(1) EM 1110-2-1902, 27 December 1960, "Stability of Earth and Rock-Fill Dams".
(2) EM 1110-2-1902, 1 April 1970, "Stability of Earth and Rock-Fill Dams".

D45. Cross-Sections. Cross-sections were selected for detailed stability analyses for the floodway, modified, and diversion channels. Included in the floodway channel sections are the stability analyses of the embankment of the relocated Baltimore and Ohio Railroad mainline and the levee. In the diversion channel section, the stability of the cut in the trash pile was analyzed, as well as the stability of the cuts and fills of the relocated Baltimore and Ohio Railroad mainline. Cross-sections were selected to reflect various channel templates and the various soil classifications. Sections were selected where it was judged that the lowest factors of safety would result. The cross-sections were simplified as required for stability analysis purposes. The phreatic lines used and the lines between different soil materials were assumed based on available information and engineering judgment. For stability analyses purposes only, the assumed top of rock used for the sections was lowered about 3 feet. This is conservative and is believed to be warranted because of irregularities in the top of rock and because of weathering and decomposition in the top few feet of rock.

D46. <u>Conditions Analyzed and Required Factors of Safety</u>. Each cross-section selected was analyzed for the following conditions:

(1) End of Construction (Case I, Paragraph 11a of EM 1110-2-1902, 1 April 1970)
(2) Sudden Drawdown from Design Water Surface (Case III, Paragraph 11 of EM 1110-2-1902, 1 April 1970)

D47. In accordance with EM 1110-2-1902, 1 April 1970, the minimum factors of safety required are as follows:

(1) End of Construction Condition______________1.3
(2) Sudden Drawdown Condition________________1.2

D48. <u>Adopted Design Values for Project Soils</u>. The adopted design unit weights and shear strength parameters for the project soils for use in the slope stability analyses are presented in Appendix A. For convenience, they are presented below. The shear test envelopes and the adopted shear strength parameters for project soils are presented in Appendix A on Plate A13. Adopted shear strength parameters are needed for the stability analysis for end of construction condition and sudden drawdown condition. For the end of construction condition, only one shear test envelope is available for the existing Baltimore and Ohio Railroad embankment material, and it was adopted for design. Also, for the end of construction condition, only one shear test envelope is available for the existing Norfolk and Western Railroad embankment material, and it was selected for design. For the end of construction condition, two shear test envelopes are available for the natural foundation material. The adopted design envelope for the natural foundation material was selected by engineering judgment, and it lies between the two shear test envelopes. For the end of construction condition, two shear test envelopes are available on project soils to be used in the relocated Baltimore and Ohio Railroad embankment and levee. The shear strength envelope selected for design was based on engineering judgment. It lies between the two shear test envelopes and is conservative. It seemed advisable to be conservative because a considerable portion of the mainline embankment material will be obtained from an offsite borrow. If shear test results on borrow material prove to be lower than the adopted shear strength parameters, considerable redesign would be involved in the project. For the sudden drawdown condition, the adopted shear strength parameters are based on the results of the consolidated-drained (CD) and consolidated-undrained (CU) shear tests. Normally for the stability analysis of a sudden drawdown condition, a combined CD-CU shear strength envelope is adopted for design. This would be the procedure for a sudden drawdown stability analysis for the upstream slope of a dam. For the Big Creek Flood Control Project, however, a true sudden drawdown condition, as with a dam, cannot occur. It was therefore felt that the refinement of a combined envelope for design was not warranted, and a straight line envelope was selected. The shear strength parameters adopted

ADOPTED DESIGN VALUES FOR PROJECT SOILS

Material	Unit Weight, PCF		Shear Strength Parameters			
			End of Construction		Sudden Drawdown	
	Moist	Saturated	ø, Degrees	C, TSF	ø, Degrees	C, TSF
(1) Earthfill for Relocated RR Embankment and Levee	125.0	130.0	11.0	0.60	22.8	0.12
(2) Existing N&W RR Embankment	125.0	130.0	2.5	0.67	20.0	0.20
(3) Existing B&O RR Embankment	125.0	130.0	0.0	0.48	18.0	0.30
(4) Natural Foundation Material	125.0	130.0	0.0	0.60	19.0	0.25
(5) Trash Material	90.0	—	30.0	0.00	30.0	0.00
(6) Riprap, Stone Ballast, and Filter Material*	125.0	—	35.0	0.00	35.0	0.00

* Adopted design values for these materials were not presented in Appendix A. Values selected are conservative. These materials take up a small part of the sections and have little effect on the results of the stability analyses.

for design are based on engineering judgment and are believed to be conservative. As with the construction case, because material for the railroad embankment will be obtained from an offsite borrow, it was felt desirable to be conservative in selecting the adopted shear parameters for the railroad embankment material. For the cut slope through the trash pile, the adopted shear strength parameters for the trash material are based on the angle of repose of the trash pile. The angle of repose of the trash pile is shown in Appendix A on Plate A14. A discussion on the adopted shear strength parameters for the trash material is presented in Appendix A. For project soils, except at the trash pile, adopted unit weights are based on laboratory tests. As no laboratory tests were run on trash pile material for the purpose of determing a unit weight, the adopted unit weight was based on the assumed unit weights of the several types of material in the trash pile. Additional discussion on the adopted unit weights is presented in Appendix A.

D49. Surcharge Loadings. Surcharge loadings, equivalent to live loadings, were used in the stability analyses and are as follows:

(1) Along the centerline of relocated Baltimore and Ohio Railroad mainline, the surcharge loading used was equivalent to 10,000 lbs./ft. distributed over a width of 10 feet.

(2) Along the top of levee, the surcharge loading used was 2 feet of earthfill (equivalent truck loading).

D50. Computer and Manual Solutions. The slope stability analyses were run using a computer program. The computer program used is based on the Circular Arc Method as presented in EM 1110-2-1902, dated 27 December 1960. The cross-sections selected for the stability analyses and the results of the computer solution are presented in Subappendix D4 on Plates D4-1 through D4-7, inclusive. A manual check was run for both the End of Construction Condition and Sudden Drawdown Condition. The purpose of the manual computations was to verify the results of the computer solution. Arc No. 2 from Plate D4-4, Left Bank Floodway Channel at Station 89+50F, was selected for the manual check. The manual check computations for the Sudden Drawdown Condition are presented in Subappendix D4 on Plate D4-8, and the manual check computations for the End of Construction Condition are presented on Plate D4-9. The manual check computations were based on Modified Swedish Method as outlined in EM 1110-2-1902, dated 1 April 1970. Consideration was given to the affects of the relocated Baltimore and Ohio Railroad mainline embankment and loadings on the stability of the Norfolk and Western Railroad embankment. The relocated mainline embankment will be adjacent to and essentially parallel to the existing Norfolk and Western Railroad embankment. At the upstream end of the relocation, the grade of the relocated Baltimore and Ohio Railroad mainline will be about 20 feet below that of the Norfolk and Western Railroad. As the relocated mainline proceeds downstream, this differential decreases uniformly and the grades of the two tracks are about level at the mainline bridge. Where there is no differential or only

a small differential between the grades of the two tracks, it is apparent that the relocated mainline embankment and loadings will have no adverse affects on the stability of the Norfolk and Western Railroad embankment. Where there is a larger differential between the grades of the two tracks, the mainline embankment is essentially acting as a stabilizing fill at the toe of the Norfolk and Western Railroad embankment. Rather than having an adverse affect, the relocated mainline embankment would be improving the overall stability of the Norfolk and Western Railroad embankment. It is significant to note that the embankment slope of the Norfolk and Western Railroad embankment is as steep as 1V on 1.5H. Whereas the embankment slope of the relocated mainline is 1V on 2.5H. Dynamic train loadings could be comparable to the vertical component of an earthquake loading but of a smaller magnitude. Normally, it can be assumed that if an embankment has adequate factors of safety for static loadings, it would be stable for small earthquake loadings. Therefore, the Baltimore and Ohio Railroad dynamic train loadings are not expected to affect the stability of the Norfolk and Western Railroad embankment. The Norfolk and Western Railroad has experienced slope stability problems with the cut slope on the north side of the Norfolk and Western Railroad track . As the Norfolk and Western cut slope is farther away from the relocated Baltimore and Ohio Railroad track than the Norfolk and Western Railroad embankment, the relocated Baltimore and Ohio Railroad track has less effect on the Norfolk and Western cut slope than it does on the Norfolk and Western Railroad embankment. Therefore, the relocated Baltimore and Ohio Railroad embankment and train loadings will have no adverse effect on the Norfolk and Western cut slope. As outlined in Paragraph D49, surcharge loadings, equivalent to live loadings, were used in the stability analysis of the *mainline embankment*.

D51. Summary of Results. Results of the computer solutions and manual check computations for the slope stability analyses are as follows:

COMPUTER SOLUTION SUMMARY

Plate No. Subappendix D4	Location	Factor of Safety: Sudden Drawdown Condition	Factor of Safety: End of Construction Condition
D4-1	Right Bank, Diversion Channel, Sta. 64+00D	1.28	1.17
D4-2	Left Bank, Diversion Channel, Sta. 64+00D	1.76	3.69
D4-3	Left Bank, Modified Channel, Sta. 80+00M	1.64	2.32
D4-4	Left Bank, Floodway Channel, Sta. 89+50F	1.50	2.52
D4-5	Left Bank, Floodway Channel, Sta. 102+00F	1.78	2.80
D4-6	Left Bank, Floodway Channel, Sta. 108+25F	2.21	3.71
D4-7	Levee, Floodway Channel, Sta. 111+00F	2.58	6.30

MANUAL CHECK SUMMARY

		Factor of Safety Manual Check	Factor of Safety Computer Solution
(1)	Sudden Drawdown Condition, Arc. No. 2, Left Bank, Floodway Channel, Sta. 89+50F (Subappendix D4, Plate D4-8)	1.58	1.50*
(2)	End of Construction Condition, Arc. No. 2, Left Bank, Floodway Channel, Sta. 89+50F (Subappendix D4, Plate D4-9)	3.44	3.49*

* Subappendix D4, Plate D4-4.

D52. Discussion on Stability Analyses. The number of arcs shown on the Plates in Subappendix D4 are representative of the arcs analyzed. In all cases the arc with the lowest factor of safety is presented.

D53. Except for the results of the stability analysis on the cut through the trash pile (Subappendix D4, Plate D4-1), the factors of safety obtained for both the End of Construction and Sudden Drawdown Conditions are considerably higher than the minimum required factor of safety. The high factors of safety obtained for the End of Construction Condition can generally be attributed to the relatively high adopted design values used for cohesion for the various soils involved.

D54. The high factors of safety obtained for the Sudden Drawdown Condition cannot be attributed to either the adopted design value for angle of internal friction or cohesion for the various soils involved. The high factors of safety obtained are believed to be attributed to a combination of factors; such as, assumed phreatic line, adopted shear parameters, and side slope.

D55. The channel side slopes used for the various sections analyzed were selected during the initial studies made in connection with the preparation of Appendix B. The side slopes selected were believed to be slightly flatter than would theoretically be required to satisfy slope stability criteria. A conservative approach was taken because if it were found that the slopes were too steep, flattening the slopes to satisfy stability criteria would result in major changes to the alignments of the floodway, modified, and diversion channels. This, in turn, would result in a delay in completion of the project design. Therefore, as expected, the side slopes are conservative, except for the diversion channel cut at the trash pile.

D56. For the diversion channel cut in the trash pile, the factor of safety for the End of Construction Condition was 1.17 compared with the minimum required value of 1.3. It is apparent that the low factor of safety is attributed to the shear strength parameters adopted for the trash pile material.

The adopted shear parameters for the trash material was 30° for angle of internal friction and zero for cohesion. A detailed discussion on how these parameters were selected is presented in Appendix A. It is believed that these parameters are on the conservative side for several reasons. The angle of inclination of the existing slope of the trash pile varies between 33° and 38°. The actual angle of internal friction is believed to be considerably more than the assumed 30°. Also, the trash material is believed to have some cohesion. A small amount of cohesion for the trash material would make the factor of safety higher. Because of these considerations, the factor of safety of 1.17 obtained is accepted. It is not believed that flattening the slope of the cut to obtain the 1.3 factor of safety is warranted.

D57. The difference in the results between the computer solution and manual check is relatively small and is considered acceptable. Since the manual check gave slightly greater factors of safety than the computer solution, the computer solution is slightly conservative. The difference can be attributed to the difference in method of analysis and also to the normal inaccuracies expected in the graphical procedure used for the manual check.

D57a. Engineering Data Required for Levee, Earthfill in Zoo Floodplain, and Railroad Embankments. Earthen material required for the levee and earthfill in Zoo floodplain will be obtained from required common excavation. Earthen material required for the railroad embankments will be obtained from both required common excavation and from the designated offsite borrow area. A detailed description of these materials along with laboratory test data is presented in Appendix A.

D57b. Material for the levee and earthfill in Zoo floodplain will consist primarily of the impervious project soils consisting of sandy, silty clay, classified as CL. The material shall contain a minimum of 20 percent passing the No. 200 sieve, and it shall have a minimum plasticity index of 3. The moisture content after compaction shall be within the limits of 2 percentage points above optimum and 2 percentage points below optimum. Material shall be compacted to 95 percent of Standard Proctor Density. The levee and earthfill in Zoo floodplain shall not have stones, rocks, and rock fragments larger than 2/3 the placement lift thickness.

D57c. Material for the railroad embankments shall consist of earth materials obtained from required excavation and designated borrow area which are suitable for use in the railroad embankments. The moisture content after compaction shall be within the limits of 2 percentage points above optimum and 2 percentage points below optimum. Material shall be compacted to 95 percent of Standard Proctor Density. The embankment shall not have stones, rocks, and rock fragments larger than 2/3 the placement lift thickness.

SECTION E

RAILROAD RELOCATIONS

D58. General. Several alignments of the relocated Baltimore and Ohio Railroad mainline and spurline were presented in Appendix B, Alternative Studies, and one alignment of the mainline and spurline was selected for final design. Since completion of the Alternative Studies, detailed field surveys of selected portions of the existing railroad facilities at the project site were performed. Accurate horizontal and vertical survey data of the existing railroad facilities was needed for finalizing the design of mainline and spurline alignments.

D59. The selected mainline and spurline alignments have been refined and coordinated to accommodate all constraints of the floodway channel, modified channel, diversion channel, Baltimore and Ohio Railroad mainline and spurline, and the Norfolk and Western Railroad.

D60. Design Criteria and Procedures. The horizontal and vertical geometry was located and coordinated in the final position using the standard design criteria furnished by the Chessie System. The horizontal criteria is based on Engineering Bulletin No. R-13, dated April 18, 1977. The vertical criteria is based on the Pamphlet package from the Chessie System, dated June 19, 1978. The track roadbed typical sections were taken from the "Roadbed and Ballast Sections for New Construction", dated January 23, 1964. The roadbed drainage for pipe locations and sizes is based on the U.S. Department of Transportation "Hydraulic Engineering Circular No. 12" and "Hydraulic Design Series No. 3". The slope stability analyses of the relocated railroad embankment sections are presented in Section D and Subappendix D4. A listing of design criteria and design calculations for the final location of the relocated mainline and the spurline alignments are presented in Subappendix D5.

BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

PHASE II
GENERAL DESIGN MEMORANDUM

APPENDIX D

DESIGN ANALYSIS

AUGUST 1979

SUBAPPENDIX D1

COMPUTATIONS FOR STRUCTURAL DESIGN
OF
HYDRAULIC STRUCTURES

SUBAPPENDIX D1

COMPUTATIONS FOR STRUCTURAL DESIGN OF HYDRAULIC STRUCTURES

CONTENTS

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT ______ FILE NO. ______
______ SHEET NO. ______ OF ______ SHEETS
FOR ______
COMPUTED BY ______ DATE ______ CHECKED BY ______ DATE ______

BIG CREEK FLOOD CONTROL PROJECT

STRUCTURAL DESIGN

CHUTE-TRANSITION AT UPSTREAM END
OF PROJECT

(INCLUDING ZOO ACCESS ROAD AND
ACCESS TO BROOKSIDE PARK DRIVE UNDERPASS)

DI-3

8312

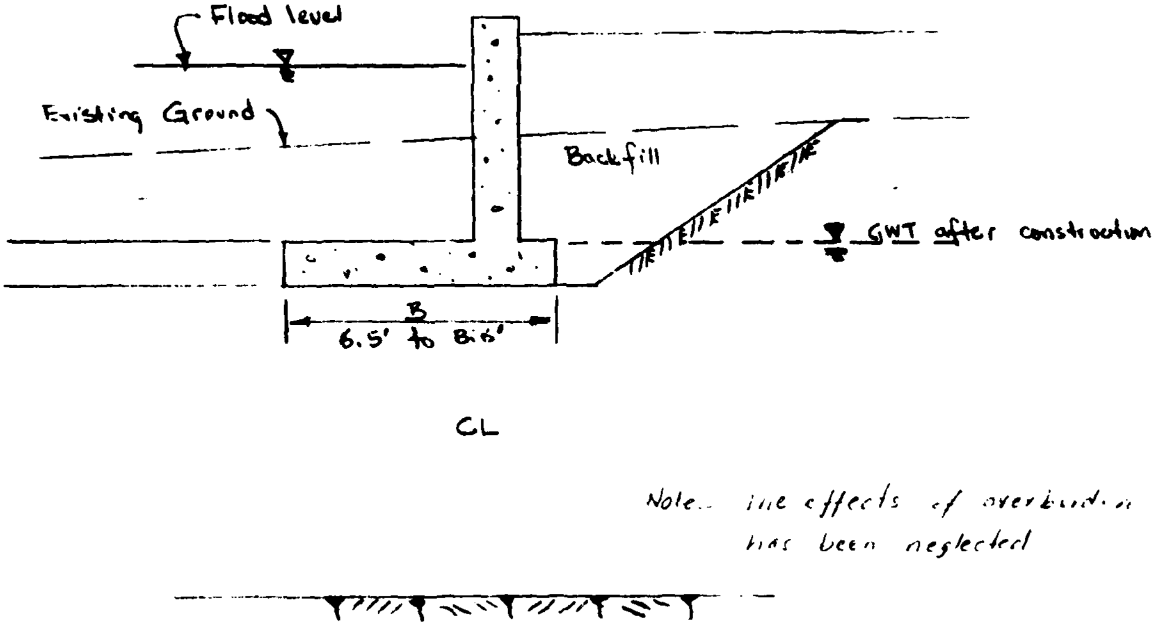
Purpose: Determine maximum allowable pressures for walls on earth foundations.

Applicability: Walls on earth foundations will be constructed at the following locations:

1. Chute - transition at upstream end of project

Preliminary Design Data:

1. Walls will be founded on CL soils.
2. Wall base will be essentially a continuous strip.



Note.. the effects of overburden has been neglected

Soil Test Data: Ref.: Phase II GDM, Appendix A

For Foundation Material:

Construction Case : $C = 0.60$ TSF $\Phi = 0°$

Sudden Drawdown : $C = 0.25$ TSF $\Phi = 19°$

$\gamma_t = 125$ pcf

Using the general bearing capacity developed by Hansen for cohesive soils (Ref.: "Foundation Analysis and Design", J.E. Bowles, 1968):

$$q_{ult} = c N_c s_c d_c i_c + W q N_q s_q d_q i_q + W' \tfrac{1}{2} \gamma B N_\gamma s_\gamma d_\gamma i_\gamma$$

Construction Case

$\gamma_E = 0.125$ KSF $C = 0.60$ TSF $= 1.20$ KSF $\phi = 0°$

From Tables:

$N_c = 5.14$	$N_q = 1.00$	$N_\gamma = 0.0$
$S_c = 1.00$	$S_q = 1.00$	$S_\gamma = 1.00$
$i_c = 1.00$	$i_q = 1.00$	$i_\gamma = 1.00$
$d_c = 1.00$	$d_q = 1.00$	$d_\gamma = 1.00$

$q = (1.5)(0.15 - 0.0625) = 0.13$ KSF ← Considering only the wt of the conc. slab.

$W = 0.5$ $W' = 0.5$

$q_{ult} = (1.2 \text{ KSF})(5.14)(1)(1.00)(1) + (0.5)(0.13 \text{ KSF})(1)(1)(1)(1) + 0$

$q_{ult} = 6.23$ KSF

Use Factor of Safety = 3.0

$q_a = 6.36/3.0 = 2.08$ KSF Use 2.0 KSF

∴ ALLOWABLE PRESSURE = 2.0 KSF for Construction Case

Flood Case (Assume water has receded in flume)

$\gamma_t = 0.125$ KSF $\quad c = 0.25$ TSF $= 0.5$ KSF $\quad \phi = 19°$

From Tables*:

$N_c = 13.93$	$N_q = 5.8$	$N_\gamma = 4.68$	* Foundation Engineering Hand book
$S_c = 1.00$	$S_q = 1.00$	$S_\gamma = 1.00$	
$i_c = 1.00$	$i_q = 1.00$	$i_\gamma = 1.00$	& Foundation Analysis J.E. Bowles.
$d_c = 1.00$	$d_q = 1.00$	$d_\gamma = 1.00$	

$q = 0.13$ KSF

$W = 0.5 \quad W' = 0.5$

$$q_{ult} = (0.5\ \text{KSF})(13.93)(1)(1)(1) + (0.5)(0.13\ \text{KSF})(5.80)(1)(1)(1)$$

$$+ (0.5)(0.5)(0.0625)(6.5)(4.68)(1)(1)(1) = 7.817\ \text{KSF}$$

$$q_a = 7.817/3.0 = 2.606\ \text{KSF} \quad (> 2.0\ \text{KSF}, \therefore \text{not critical})$$

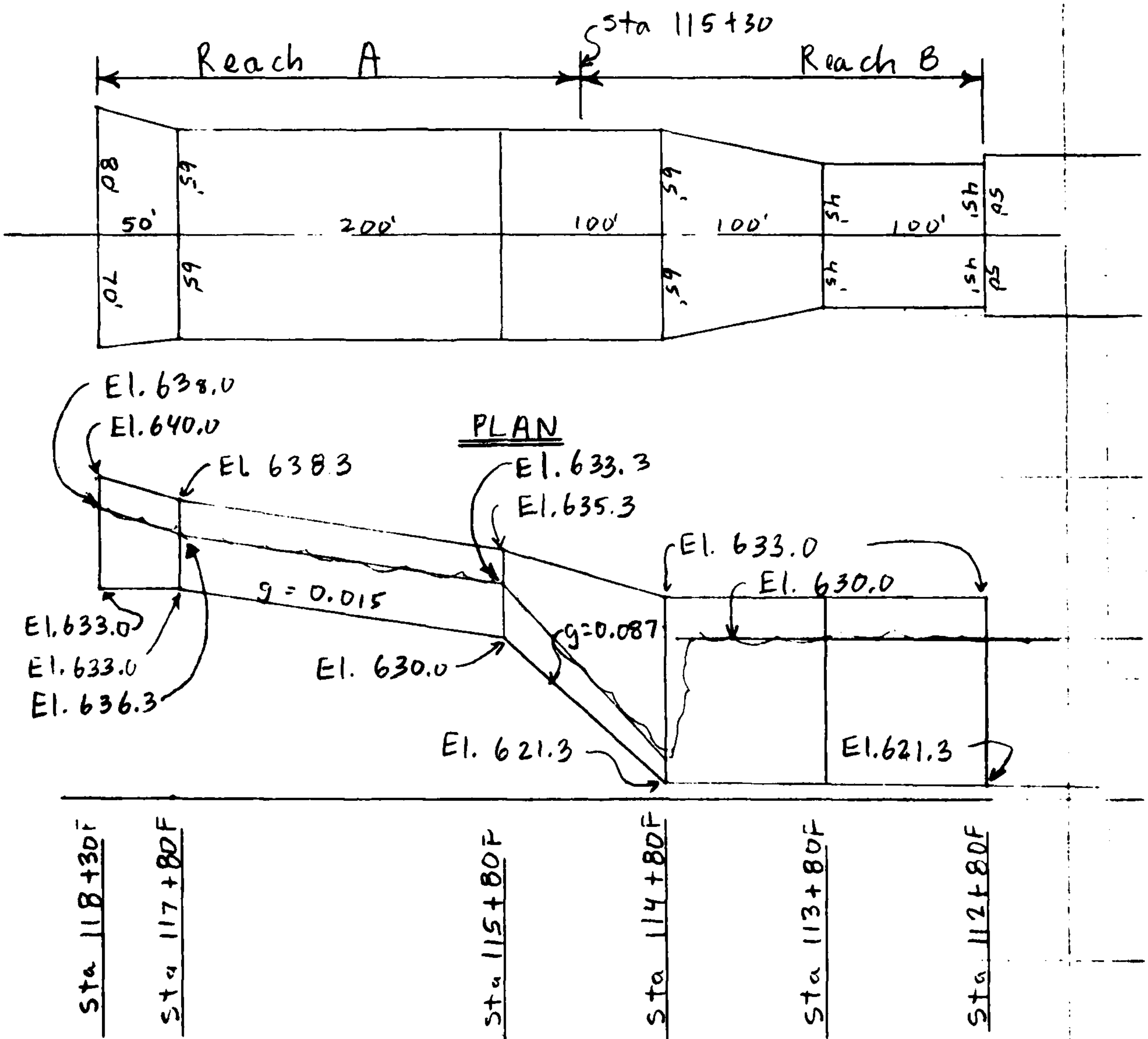
ADOPTED DESIGN VALUE FOR ALLOWABLE PRESSURE	=	2.0 KSF

8819

GANNETT FLEMING CORDDRY AND CARPENTER, INC. HARRISBURG, PA.	SUBJECT: CHUTE - TRANSITION BIG CREEK FLOOD CONTROL PROJECT FILE NO. 7622.00 SHEET NO. 1 OF ___ SHEETS
	FOR ___
	COMPUTED BY TvdC DATE 11/28/78 CHECKED BY EFM DATE 3-2-79

PLAN & PROFILE

Scale 1" = 100' H
1" = 10' V



PROFILE

Scale: H: 1" = 100'
V: 1" = 10'

D1-7

6819

LOADING CONDITIONS.

CASE I. Sudden Drawdown.

(a) Chute - Transition empty.
(b) Backfill at max. elevation.
(c) Backfill submerged to an elev. midway betn design Water surface and bottom of slab.
(d) Backfill above the level of submergence naturally drained.
(e) Lateral earth pressure based on $K_{active} = 0.33$.
(f) Uplift across the base varies from reduced hydrostatic head at the heal to 3-foot at inside face of wall, Uniform 3.0' Uplift on the rest of the base.

CASE II. Design Flood.

(a) Water Surface at design elev. (2.0' below top of wall)
(b) Backfill at min. elev.
(c) Back fill naturally drained
(d) Uplift varying uniformly across the base.

+ Reaches A & B will be designed for case (I)

+ Betn Sta. 115+55^F and Sta 116+05^F in Reach A CASE II is considered for right bank.

6819

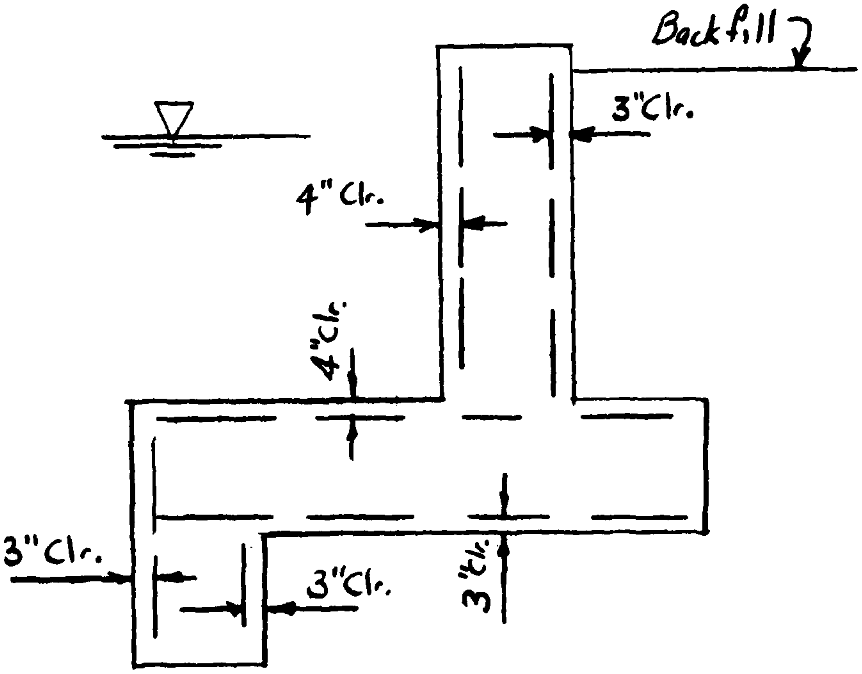
TEMPERATURE AND SHRINKAGE REINFORCEMENT

Reference EM 1110-2-2103, Para. 10 b (1)

A_s = 0.20 % of gross cross-sectional area, half in each face.
Considering Cleveland is in a region of severe climatic temperature conditions, add 25 %.
$\therefore$ $A_s = 0.20 + 0.05 = 0.25\%$
A_s = 0.125 % of gross cross-sectional area in each face

CLEARANCES

Reference EM 1110-2-2103, Para. 8



8819

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

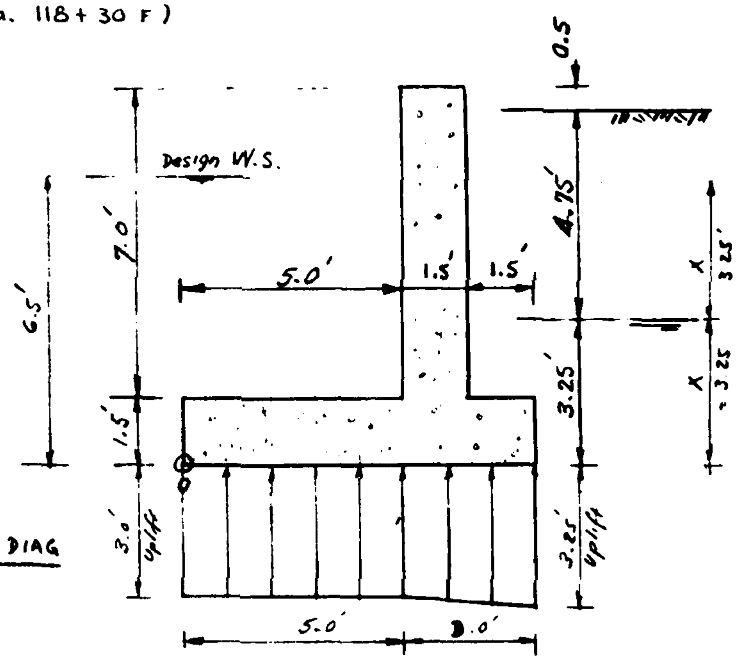
SUBJECT: STRUCTURAL DESIGN, L-WALL — FILE NO. 7622
CHUTE - TRANSITION AT UPSTREAM END — SHEET NO. 3 OF ___ SHEETS
FOR: BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY: FFM — DATE: 3-1-79 — CHECKED BY: DBW — DATE: 3-3-79

I. REACH "A"

A. SUDDEN DRAWDOWN CONDITION.

1. Critical Section Dimensions.

(At Sta. 118 + 30 F)



2. Adopted Design Values:

$\gamma_{sat\,(soil)} = 125.0$ pcf

$\gamma_{conc} = 150.0$ pcf

$\gamma_w = 62.5$ pcf

$K_{active} = 0.33$

$K_{act}\gamma_{sat} = .0417$ K/ft^2

$K_{act}\gamma_{sub} = .021$ " "

$\gamma_w + K_{act}\gamma_{sub} = .083$ " "

$f_{s\,ten} = 20{,}000$ psi

$f_c = 1{,}050$ "

$n = 9.2$

8818

3. Stability Table

Item	Computations		Horz ←	Vertical ↓	Vertical ↑	Arm	Moment ↻	Moment ↺
Conc.	7.0 x 1.5 x .150	stem		1.575		5.75	9.056	
	8.0 x 1.5 x .150	base		1.800		4.00	7.200	
Soil	1.5 x 6.5 x .125	ut		1.219		7.25	8.836	
"	4.75^2 x .0417/2		.470			4.83		2.272
	4.75 x 3.25 x .0417		.643			1.625		1.046
	3.25^2 x .0833/2		.440			1.083		0.477
Uplift	3.0 x .0625 x 8.0				1.500	4.0		6.000
	0.25 x .0625 x 3/2				.023	7.0		0.164
			1.553	4.594	1.523		25.092	9.959
	Total		1.553	3.071		4.928'	15.133	

$e = .928' < \frac{\ell}{6}$ o.K.

Check Sliding

$$\frac{\Sigma H}{\Sigma V} = \frac{1.553}{3.071} = 0.506 < 0.60 \quad \text{O.K.}$$

4. Stresses on the foundation

$$f_x = \frac{V}{\ell^2}(\ell - 6e) + \frac{V}{\ell^3}(12e)\,x$$
$$= 0.1167 + .0668\,x$$

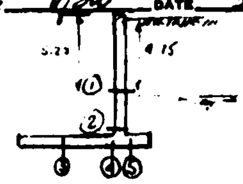
$f_0 = 0.1167$ K/ft² @ pt. 0
$f_{2.5} = 0.2837$ " " 2.5' from 0
$f_{5.0} = 0.4507$ " " 5.0' " "
$f_{6.5} = 0.5509$ " " 6.5' " "
$f_{8.0} = 0.6511$ " " 8.0' " "

All < 2.0 K/ft² OK

8818

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT: STRUCTURAL DESIGN, L-WALL — CHUTE TRANSITION AT UP-STREAM END FILE NO. 7622
SHEET NO. 5 OF ___ SHEETS
FOR: BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY: FEM DATE: 3-1-79 CHECKED BY: RJBW DATE: 3-3-79



5- STRESS ANALYSIS

PT.	(N) Normal Force: Comps	(N) Normal Force: Value (K)	(Q) Shearing Force: Comps	(Q) Shearing Force: Value (K)	Arm	(M) Moment: Comps	(M) Moment: Value (K-ft)
①	5.25 X 1.5 X .15	1.180	4.75^2 x .0417/2	0.470	1.583	0.470 x 1.583	0.745
②	7.0 X 1.5 X .15	1.575	4.75^2 x .0417/2	0.470	3.333	0.470 X 3.333	1.567
			+ 4.75 x 1.75 x .0417	0.347	0.875	0.347 X 0.875	0.303
			+ 1.75^2 x .0833/2	0.128	0.583	0.128 X 0.583	0.074
				0.945			1.944
③	$\frac{1.523}{8}$ x 2.5	0.476	(0.1167 + 3x.0625 − 1.5 x .15) 2.5	0.1980	1.25	0.198 x 1.25	0.2475
			(.2837 − .1167) $\frac{2.5}{2}$	0.2088	0.833	0.2088 x 0.833	0.1739
		0.476		0.4068			0.4214
④	$\frac{1.523}{8}$ x 5	0.952	0.1167 + 3x.0625 − 1.5 x .15) 5	0.3960	2.50	0.396 x 2.50	0.9900
			(.4307 − .1167) $\frac{5}{2}$	0.8350	1.667	0.835 x 1.667	1.3945
		0.952		1.2310			2.3845
⑤	1.523 x $\frac{6.5}{8}$	1.237	(.125 x 6.5 + .150 x 1.5) 1.5	1.556	0.75	1.556 x 0.75	1.167
			− [(.5509 + .15H)/2 + 3.25 x .0625] 1.5	− 1.206	0.75	− 1.206 x 0.75	− 0.904
		1.237		0.350			0.263

6812

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT STRUCTURAL DESIGN, L-WALL CHUTE - TRANSITION FILE NO. ______ SHEET NO. ____ OF ____ SHEETS
FOR BIG CREEK
COMPUTED BY FFM DATE 7-13-79 CHECKED BY ______ DATE ______

6. Reinforcement.

Reference: ACI Publication SP-3, Reinforced Concrete Design - Working Stress Method.

Since moments are small consider max.

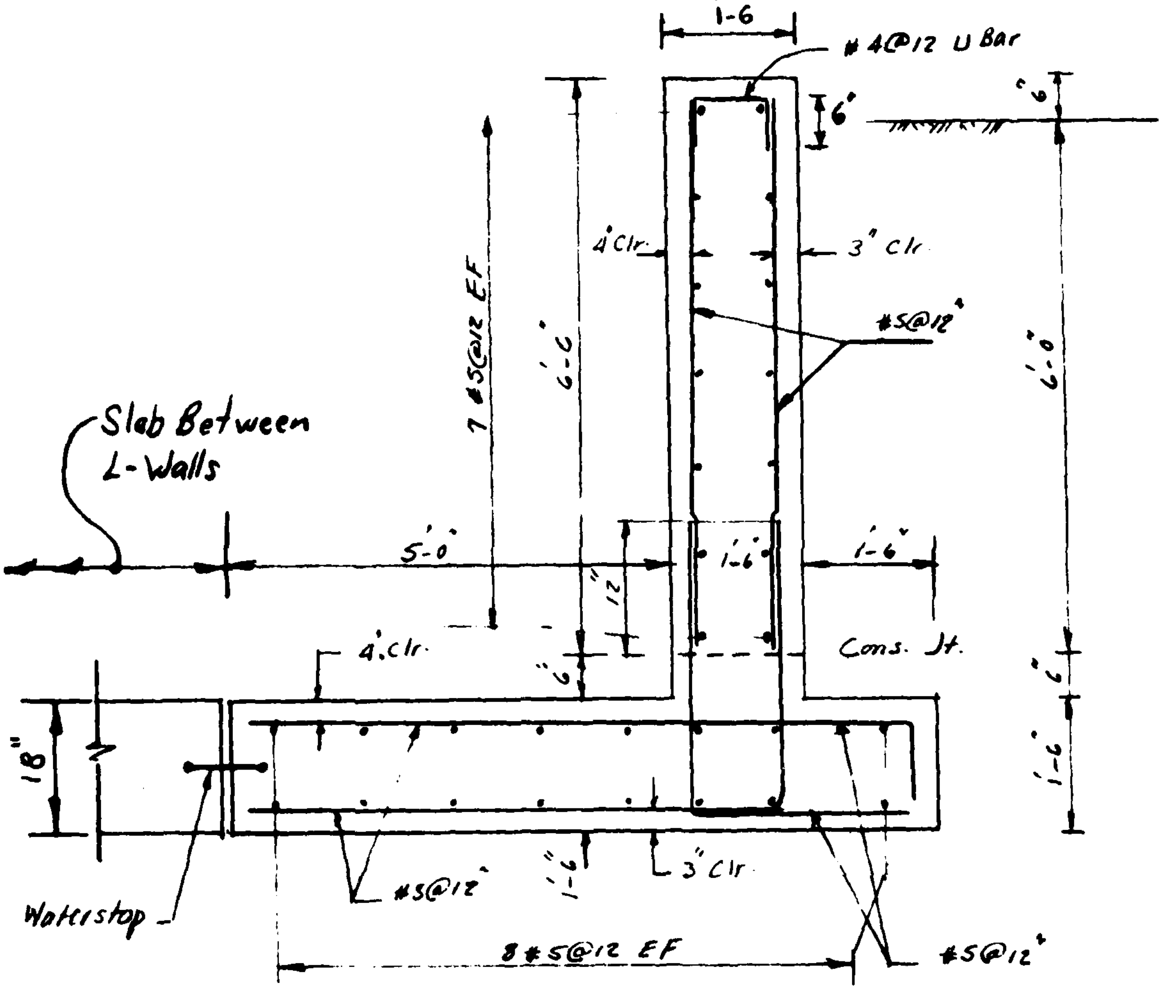
$A_s = M / ad$
M = Moment = 2.3845 K-Ft.
d = Effective depth in flexural members
d = 14.5", t = 18"
a = Coefficient = $f_s j / 12000$ = 1.48
$A_{s(1)}$ = 2.3845 / 1.48 × 14.5 = 0.11 in²/ft

Tempature & Shrinkage Steel:
A_s = 0.125 × 12 × 18 / 100 = 0.27 in²/ft.

Use #5 @ 12 EW, EF (0.31 in²/ft)

6819

NOTE: The base of the L-Wall is designed to match the slabs between the two L-Walls. The slabs are designed to resist an uplift of 3 feet. See slab design Page D1-31.



Reinforcement Details.

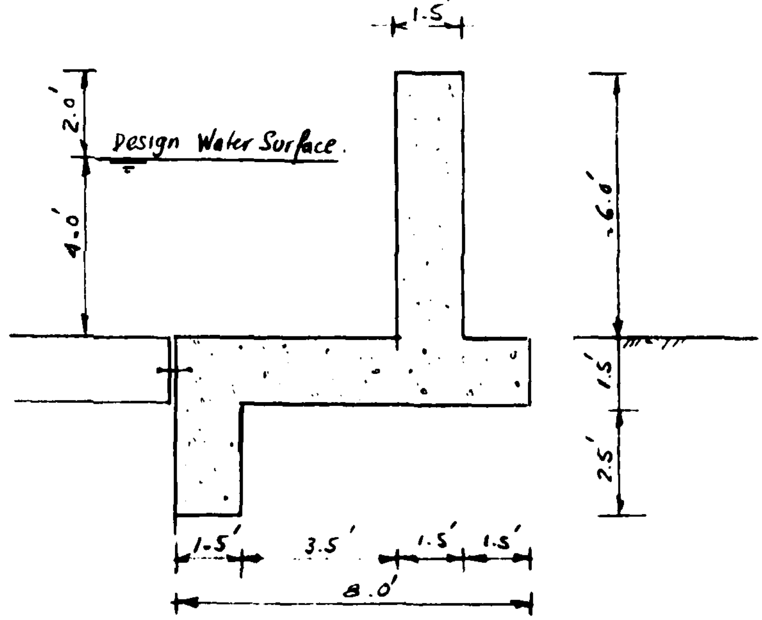
scale 1" = 2.0'

8313

B. DESIGN FLOOD CONDITION.

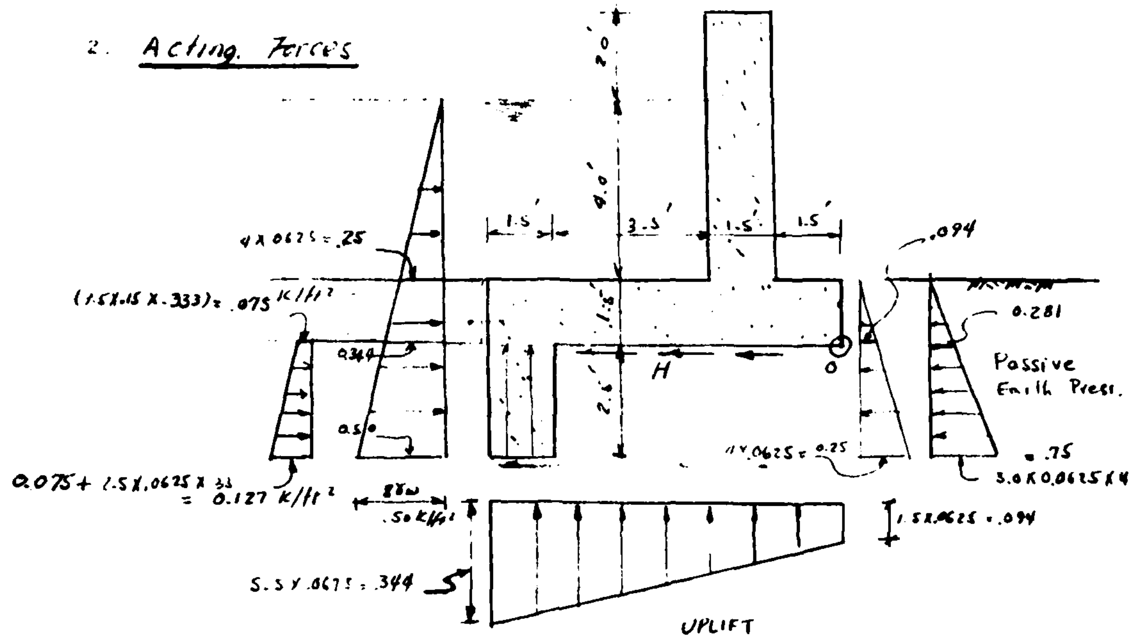
Around Sta 115+80 F there is no backfill behind the wall. Consequently, the wall should design as a floodwall betn. sta. 115+55 F and sta. 116+05 F.

1. Critical Section Dimensions.



6818

2. Acting Forces



3. STABILITY TABLE

Item	Computations	Horizontal →	Horizontal ←	Vertical ↓	Vertical ↑	Arm	Moment ↻	Moment ↺
Conc.	6.0 x 1.5 x .15			1.350		2.25		3.038
	8.0 x 1.5 x .15			1.800		4.00		7.200
	2.5 x 1.5 x (.15 - .0625)			0.328		7.25		2.378
Water	5 x 4 x .0625			1.25		5.50		6.875
	1.5 x 0.0625 x 8.0/2				0.375	2.667	1.000	
	5.5 x 0.0625 x 8/2				1.375	5.333	7.333	
	$8.^2$ x 0.0625/2	2.000				0.167	0.334	
	4.0^2 x 0.0625/2		0.50			-1.168	0.584	
Soil	0.075 x 2.5/2	0.094				-.833		0.079
	0.127 x 2.5/2	0.159				-1.667		0.265
Passive	3.0 x .0625 x 4^2/2		1.50			-1.167	1.750	
	Subtotal	2.254	2.000	4.728	1.750		11.001	19.835
						o		
	TOTAL	.254 = H		2.978		2.967		8.834

$e = 1.033 < l/6$ O.K.

Sliding Coefficient.

$$\frac{\Sigma H}{\Sigma V} = \frac{0.254}{2.978} = 0.085 < .60 \text{ OK}$$

4- Stresses on Foundation

$$e = x' - \frac{\ell}{2} = 2.967 - 4.0 = -1.033 < \ell/6$$

(Resultant within Midthird)

$$f_x = \frac{V}{\ell^2}(\ell - 6e) + \frac{V}{\ell^3}(12e)x$$

$= 0.6607 - .0721\ x$

$f_0 = 0.6607$ K/ft²

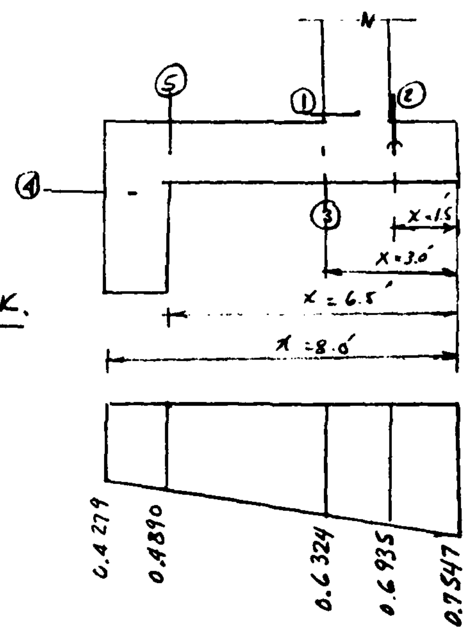
$f_{1.5} = 0.5525$ "

$f_{3.0} = 0.4444$ "

$f_{6.5} = 0.1920$ "

$f_{8.0} = 0.0839$ "

All < 2.0 ∴ O.K.



Uplift

$U_0 = 1.5 \times .0625 = 0.094$ K/ft

$U_{1.5} = (1.5 + \frac{1.5}{2}) \times .0625 = 0.141$ "

$U_{3.0} = (1.5 + \frac{3.0}{2}) \times .0625 = 0.1875$ "

$U_{6.5} = (1.5 + \frac{6.5}{2}) \times .0625 = 0.297$ "

$U_{8.0} = (1.5 + \frac{8}{2}) \times .0625 = 0.344$ "

Total Stress.

@ x = 0,	0.6607 + 0.094	= 0.7547	K/ft²
x = 1.5	0.5325 + 0.141	= 0.6935	"
x = 3.0	0.4444 + 0.188	= 0.6324	"
x = 6.5	0.1920 + 0.297	= 0.4890	"
x = 8.0	0.0839 + 0.344	= 0.4279	"

6813

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT STRUCTURAL DESIGN, L-WALL FILE NO. 7622
CHUTE - TRANSITION AT UPSTREAM END SHEET NO. 10 OF ___ SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FFM DATE 3-1-79 CHECKED BY [illegible] DATE 3-3-79

5. STRESS ANALYSIS.

PT	(N) Normal Force		(Q) Shearing Force		Arm	(M) Moment	
	Comps	Values	Comps	Value		Comps	Value
1	1.5 X 6.0 X .15	1.350	$.3625 \times 4^2/2$	0.500	1.33	0.500 X 1.333	0.667
2	$(0.094 + 0.281)\frac{1.5}{2}$	0.281	$(0.7547+0.6935)\frac{1.5}{2}$	1.086	0.75	0.748 X 0.75	0.561
	$\frac{0.254}{8} \times 1.5$	0.048	-(1.5 X .15) 1.5	- 0.338	0.75		
	comp.	0.329		.748			
3	$-0.0625 \times 4^2/2$	- 0.500	6 X 1.5 X .15	+ 1.350	0.75	+ 1.350 X .75	+ 1.013
	$+ (.094 + 0.281)\frac{1.5}{2}$	+ 0.281	+ 3 X 1.5 X .15	+ 0.675	1.50	+ 0.675 X 1.50	+ 1.013
	$+ \frac{.254}{8} \times 3$	+ 0.095	$-(.7547+.6324)\frac{3}{2}$	- 2.081	1.5	- 2.081 X 1.5	- 3.121
						(W) 0.5 X 2.08	+ 1.042
	Tens.	- 0.124		- 0.056			- 0.050
4	- 2.5 X 1.5 (.15 - .0625)	- 0.328	$+(.094+.281)\frac{2.5}{2}$	+ 0.469	0.833	+ 0.469 X .833	+ 0.390
	$+(.4890+.4279)\frac{1.5}{2}$	+ 0.688	$+(0.25+0.75)\frac{2.5}{2}$	+ 1.250	1.667	+ 1.250 X 1.667	+ 2.084
			$-(.075+.344)\frac{2.5}{2}$	- 0.524	0.833	- 0.524 X .833	- 0.436
			$-(.127+0.50)\frac{2.5}{2}$	- 0.784	1.667	- 0.784 X 1.667	- 1.306
	Comp.	0.360		0.411			0.732
5	+ 0.25 X 4 /2	+ 0.500	4 X .0625 X 1.5	+ 0.375	.583	0.500 X .583	- .292
	+ 0.500 X 4/2	+ 1.000	+ 4 X .15 X 1.5	+ 0.900	1.917	1.000 X 1.917	- 1.917
	+ 0.075 X 2.5/2	+ 0.094	- 2.5 X .062 X 1.5	- 0.234	1.583	0.094 X 1.583	- 0.149
	+ 0.127 X 2.5/2	+ 0.159	$-(.4279+.489)\frac{1.5}{2}$	- 0.688	2.417	0.159 X 2.417	- 0.384
	$-(0.094+.281)\frac{2.5}{2}$	- 0.469			1.583	0.469 X 1.583	+ 0.743
	$-(0.25+0.75)\frac{2.5}{2}$	- 1.250			2.417	1.250 X 2.417	+ 3.021
	$-\frac{0.254}{8} \times 1.5$	- 0.048			3.25	0.048 X 3.25	+ 0.155
				+ 0.353	0.75	0.353 X .75	- 0.264
							+ 0.913

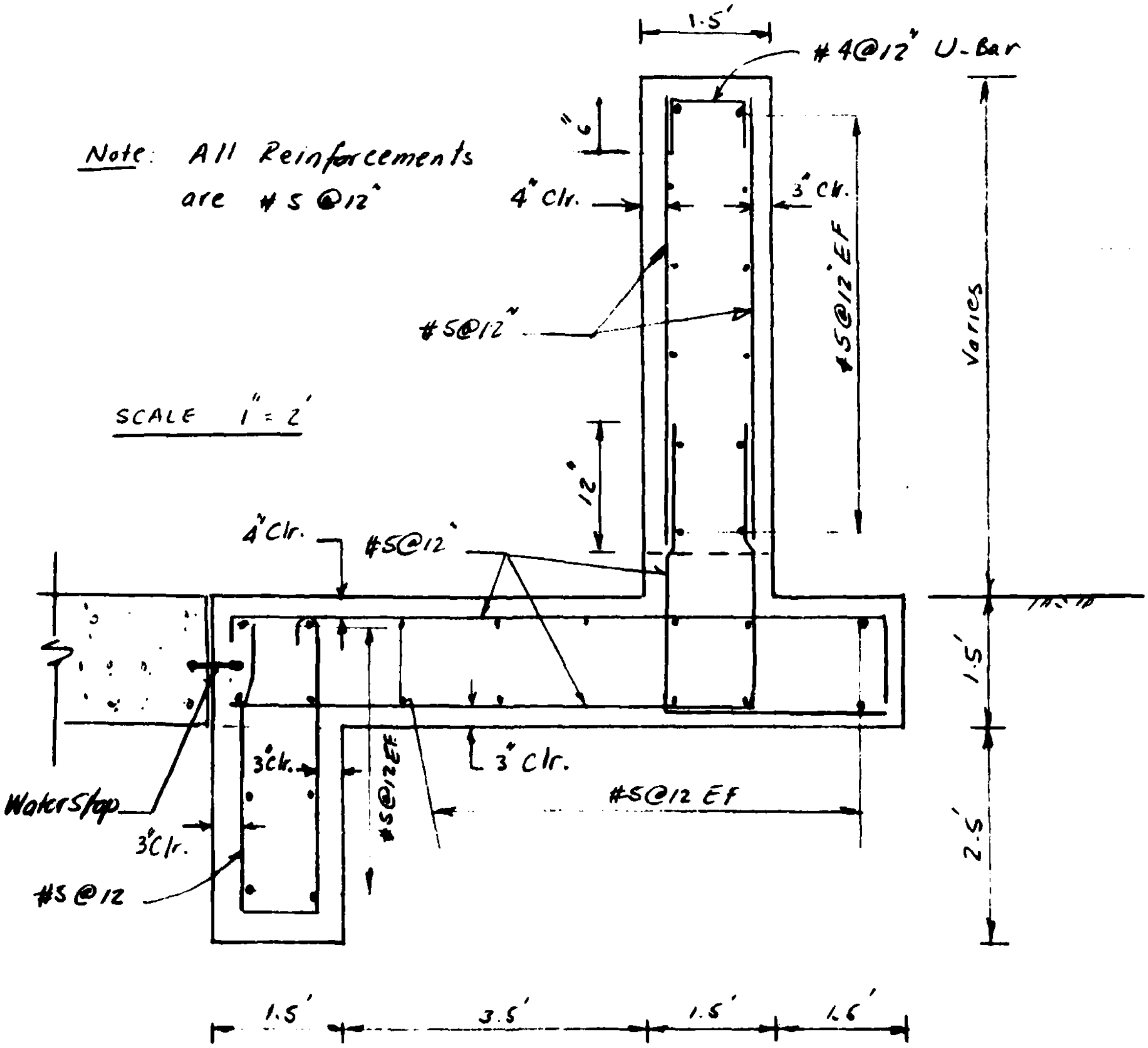
8810

Max Moment = 0.913 K.Ft. , t = 18", d = 13.5"

$A_{s\,req} = \frac{M}{ad} = \frac{0.913}{1.48 \times 13.5} = .046\ \square''$

Temp. Reinf = $\frac{0.125}{100} \times 18 \times 12 = 0.270\ \square''$

USE # 5 @ 12" E.W. E.F.
= (.310□")



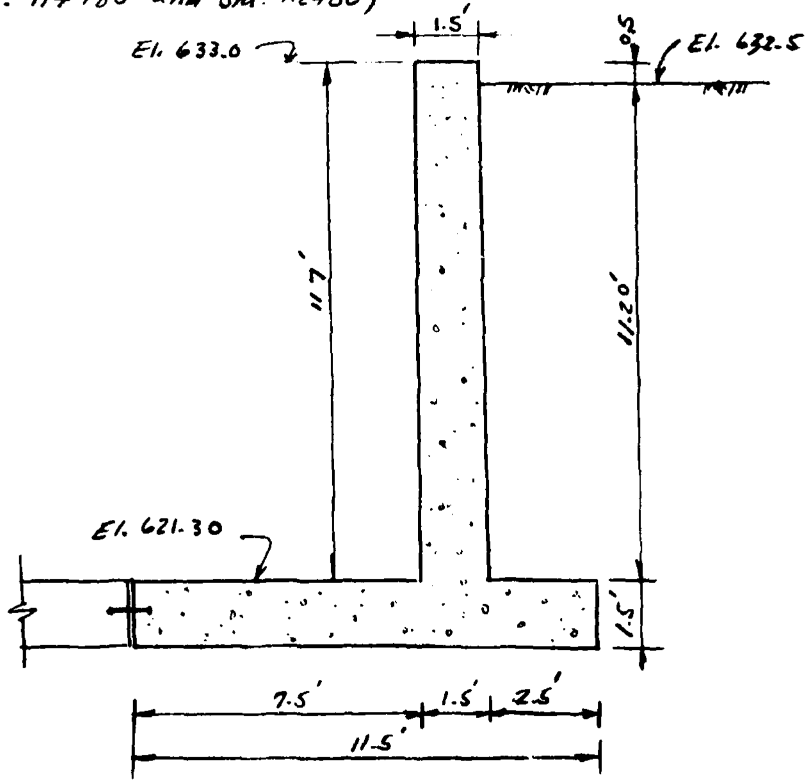
6815

II. REACH "B"

SUDDEN DRAWDOWN CONDITION

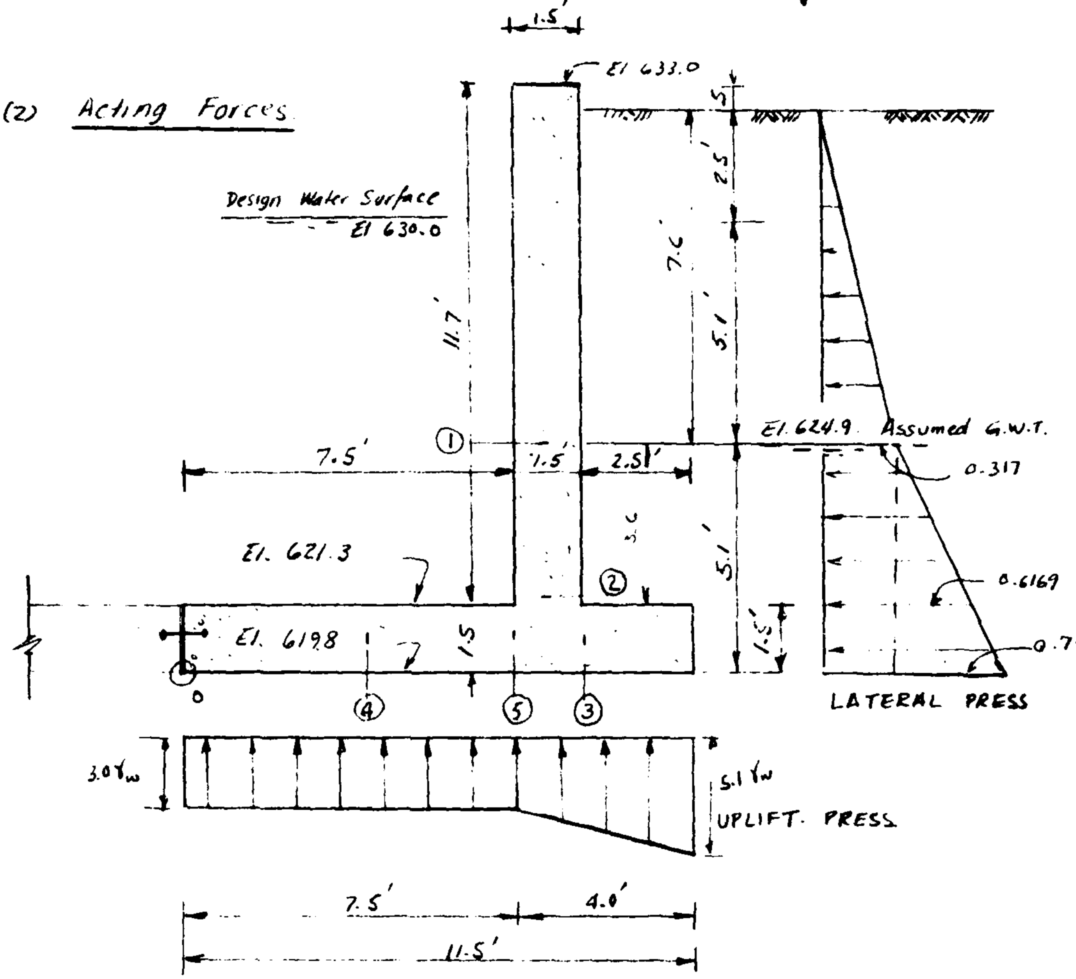
(1) Critical Section Dimension.

(Betn. Sta. 114+80 and Sta. 112+80)



6319

(2) Acting Forces



$\gamma_{conc} = 150.0$ pcf

$\gamma_{sat} = 125.0$ pcf

$\gamma_w = 62.5$ pcf

$K_{act} = 0.33$

$K_{act}\gamma_{sat} = 0.0417 \quad K/ft^2$

$K_{ac}\gamma_{sub} + \gamma_w = 0.833 \quad$ " "

8318

3. Stability Table

Item	Computations	Horiz ←	Vertical ↓	Vertical ↑	Arm	Moment @ O ↻	Moment @ O ↺
Conc.	11.7 X 1.5 X 0.150		2.633		8.25	21.722	
	11.5 X 1.5 X 0.150		2.588		5.75	14.878	
Soil	11.2 X 2.5 X 0.125 (wt)		3.500		10.25	35.875	
	7.6^2 X 0.0417 / 2	1.204			7.63		9.191
	7.60 X 5.10 X .0417	1.616			2.55		4.120
	5.1^2 X .0833 / 2	1.083			1.70		1.842
Uplift	3.0 X .0625 X 11.5			2.156	5.75		12.398
	(5.1 − 3.0) .0625 X 4/2			0.263	10.167		2.674
		3.903	8.721	2.419		72.475	30.225
	Total.	3.903	6.302		6.704	42.250	

$e = .954 < l/6$ OK.

Sliding factor. $\frac{\Sigma H}{\Sigma V} = \frac{3.903}{6.302} = .619 \approx$ Assume 0.6 O.K.

4. Stresses on the foundation.

$$f_x = \frac{V}{l^2}(l - 6e) + \frac{V}{l^3}(12e)\,x$$
$$= 0.275 + .0474\,x$$

				Uplift		Total.
$f_0 =$	0.275	K/ft^2	+	0.1875	=	0.4625
$f_{4.0} =$	0.465	"	+	0.1875	=	0.6522
$f_{7.5} =$	0.631	"	+	0.1875	=	0.8183
$f_{9.0} =$	0.702	"	+	$[(5.1-3.0)\frac{1.5}{4} + 3].0625$ = 0.2367	=	0.9383
$f_{11.5} =$	0.821	"		5.1 x .0625 = .3188	=	1.1398

All < 2.0 ∴ O.K

$\Sigma H / l = 3.903 / 11.5 = 0.339\ K/ft^2$

8818

Gannett Fleming Corddry and Carpenter, Inc.
Harrisburg, Pa.

SUBJECT Structural Design, L. Wall FILE NO. 1612
Chute Transition at Upstream End SHEET NO. 15 OF ___ SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY FFM DATE 3-2-79 CHECKED BY QAW DATE 3-3-79

5. Stress Analysis

PT.	(N) Normal Force		(Q) Shearing Force		Arm	(M) Moment	
	Comps	Value	Comps	Value		Comps	Values
①	8.1 x 1.5 x .15	1.823	$7.6^2 \times .0417/2$	1.204	2.533	1.204 x 2.533	3.051
②	11.7 x 1.5 x .15	2.633	$7.6^2 \times .0417/2$	1.204	6.133	1.204 x 6.133	7.384
			7.6 x 3.6 x .0417	1.141	1.800	1.141 x 1.800	2.054
			$3.6^2 \times .0833/2$	0.540	1.200	0.540 x 1.20	0.648
		2.633		2.885			10.086
③	0.6169 x 1.5/2	0.4627	11.2 x 2.5 x .125	+ 3.500	1.25	3.5 x 1.25	+ 4.375
	+ 0.7418 x 1.5/2	+ 0.5564	1.5 x 2.5 x .15	+ 0.563	1.25	0.563 x 1.25	+ 0.703
	− 0.339 x 2.5	− 0.848	− 0.9383 x 2.5/2	− 1.173	0.833	1.177 x 0.833	− 0.977
			− 1.1398 x 2.5/2	− 1.425	1.667	1.425 x 1.667	− 2.375
		0.1711		+ 1.461			+ 1.726
④	0.339 x 4.0	1.356	0.4625 x 4/2	0.925	2.667	0.925 x 2.667	2.467
			0.6522 x 4/2	1.304	1.333	1.304 x 1.333	1.739
			− 1.5 x .15 x 4	− 0.900	2.00	0.900 x 2.00	− 1.800
		1.356		1.329			2.406
⑤	0.339 x 7.5	2.543	0.4625 x 7.5/2	1.734	5.00	1.734 x 5.00	8.672
			0.8185 x 7.5/2	3.069	2.50	3.069 x 2.50	7.672
			− 1.5 x .15 x 7.5	− 1.688	3.75	1.688 x 3.75	− 6.328
		2.543		3.115			10.016

6513

5a. Reinforcement Design.

Reference: ACI Publication SP-3, Reinforced Concrete Design Handbook, Working Stress Method.

Terminology of Non-Standard Terms

N = Axial load normal to cross section (kips)
E = Eccentricity measured from tensile steel axis (ft.)
K = Coefficient; $K = \frac{f_c j k}{2}$
F = Coefficient used to determine the ability of section to resist moment
$F = bd^2/12000$

NE = Moment at the axis of tensile steel for section subject to bending combined with normal load.

KF = The resisting moment of the section by the tensile reinforcement only (without compression steel)

a = coefficient in $A_s = \frac{M}{ad}$ and in $A_s = \frac{NE}{adi}$

A_s = Area of tensile reinforcement
M = External moment (ft.-kips)
d = Effective depth of flexural members (in.)
$i = 1/1-\frac{jd}{e}$; e = eccentrity in inches

6. Reinforcement Requirements.

At pt ① $M = 3.051^{K}$, $N = 1.823^{K}$ comp.
$Q = 2.533^{K}$

$t = 18''$, $b = 12''$, $d = 14.5$, $d'' = 5.5$

$e = \frac{12(M)}{N} + d'' = \frac{12(3.051)}{1.823} + 5.5 = 25.58''$

$E = e/12 = 25.58/12 = 2.13'$

$e/d = 25.58/14.5 = 1.76 \rightarrow i = 1.99$

$NE = 1.823 \times 2.13 = 3.886$ K. Ft

$KF = 152 \times 0.21 = 31.920$ " (No Comp. Reinf. Req.)

$A_s = \frac{NE}{adi} = \frac{3.886}{1.44 \times 14.5 \times 1.99} = 0.0935$ sq. in

use #5@12" (.31 □")

At pt ②

$M = 10.086^{'K}$ $N = 2.633^{K}$ comp. $Q = 2.885^{K}$.

try $t = 18''$, $b = 12''$, $d = 14.5''$ $d'' = 5.5''$

$e = \frac{12(10.086)}{2.633} + 5.5'' = 51.47'' \rightarrow E = 4.29'$, $e/d = 3.55$

$i = 1.33$

$NE = 2.633 \times 4.29 = 11.296$ KF

$KF = 152 \times 0.21 = 31.920$ ~ (No Comp Reinf Req.)

$A_s = \frac{NE}{adi} = \frac{11.296}{1.44 \times 14.5 \times 1.33} = 0.407$ sq in

#5@6" (.62□")

$v = \frac{2.885 \times 1000}{12 \times 14.5} = 16.28$ psi O.K.
< 60

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT STRUCTURAL DESIGN, L-WALL FILE NO. 7622
CHUTE TRANSITION AT UPSTREAM END SHEET NO. 17 OF ___ SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FFH DATE 3-2-79 CHECKED BY D.Bur DATE 3-9-79

At pt ③ $M = 1.728^{'K}$, $N = .1711^{K}$, $Q = 1.461^{K}$

(moment, Normal force are smaller than at pt ①.
∴ Use #5 @ 12" (Min Temp. Reinf)

At pt ④ $M = 2.406^{'K}$, $N = 1.356^{K}$, $Q = 1.329^{K}$

(moment, normal force are smaller than at pt ①

∴ Use #5@12" (Min Temp. Reinf.)

At pt ⑤

$M = 10.016^{'K}$ $N = -2.543^{K}$, $Q = 3.115^{K}$

Moment & Normal force are compatable

to those at pt ②

USE #5 @ 6"

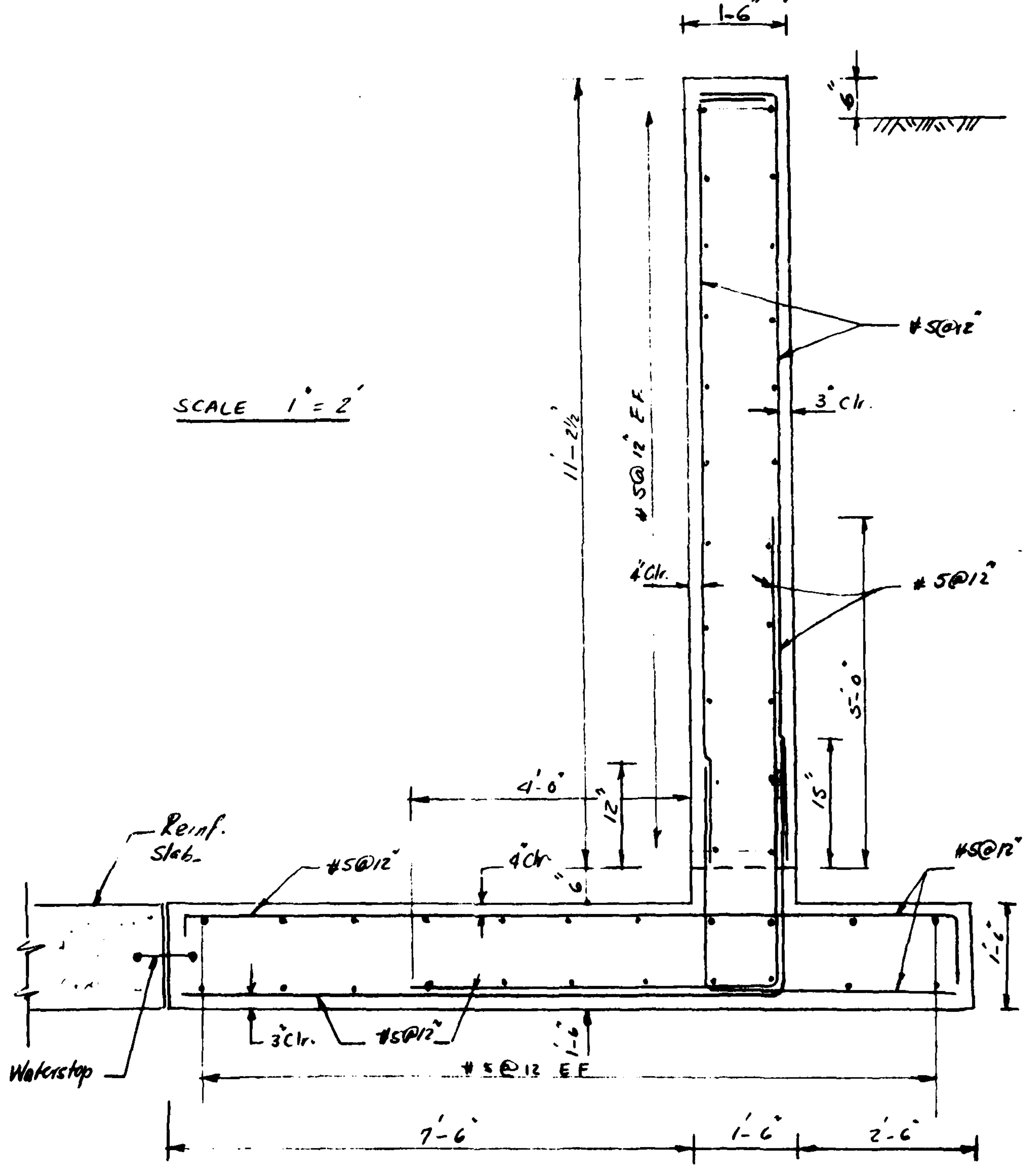
$$q = \frac{3115}{14.5 \times 12} = 17.9 < 60 \text{ psi}$$

O.K.

8819

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT STRUCTURAL DESIGN, L-WALL FILE NO. 7622
CHUTE TRANSITION AT UPSTREAM END SHEET NO. 18 OF ___ SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FFM DATE 3-2-79 CHECKED BY DBW DATE 3-3-79



6813

SLAB AND SUBDRAINAGE SYSTEM

References

(1) ETL 1110-2-236, "Design Criteria - Paved Concrete Flood Control Channels", 30 June 1978.
(2) EM 1110-2-2103, "Details of Reinforcement - Hydraulic Structures", 21 May 1971.
(3) EM 1110-2-2502, "Retaining Walls", 29 May 61.

Discussion on Design

ETL 1110-2-236 outlines the procedure for design of a paved concrete slab for flood control projects. Although the chute-transition is not exactly a paved channel, some of the design criteria in the ETL is believed to be applicable. An important feature of the design is the subdrainage system. An excerpt from the ETL is as follows: "Selection of locations for soil plugs and drain outlets needs to consider the profile for maximum ground water surface. For cases where the water table will not be above the channel invert, a subdrainage system will not be required."

The chute-transition for the Big Creek Flood Control Project is different from a channel for an ordinary Flood Control Project in that it is not located in the main stream. The present water table at the downstream end of the chute-transition is about 1 foot above slab grade. After completion of the project, it is expected that the normal water table will be below the slab grade. The upstream end of the chute-transition is above the two-barrel conduit.

SLAB AND SUBDRAINAGE SYSTEM

Discussion on Design (Cont'd.)

The normal water table along this reach is expected to be below the slab grade.

The above factors must be taken into consideration in design. Also, consideration must be given to the fact that the chute-transition will be used as a roadway for John Nagy Boulevard.

Subdrainage System

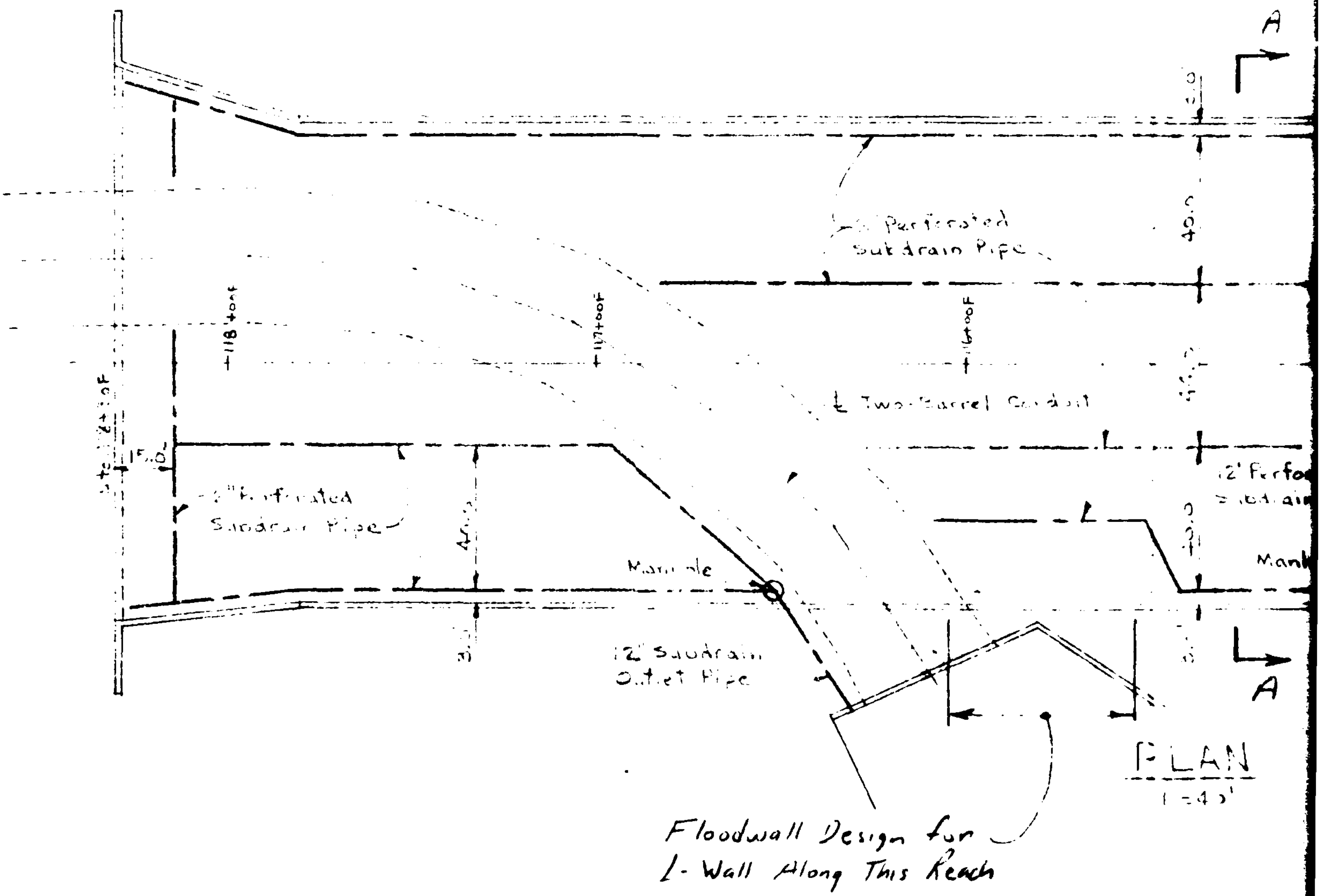
The subdrainage system will generally consist of 6" gravel drain material on filter material with 6" Dia. perforated pipes placed longitudinally. Outlets will be provided. A plan and section are shown on the following sheets.

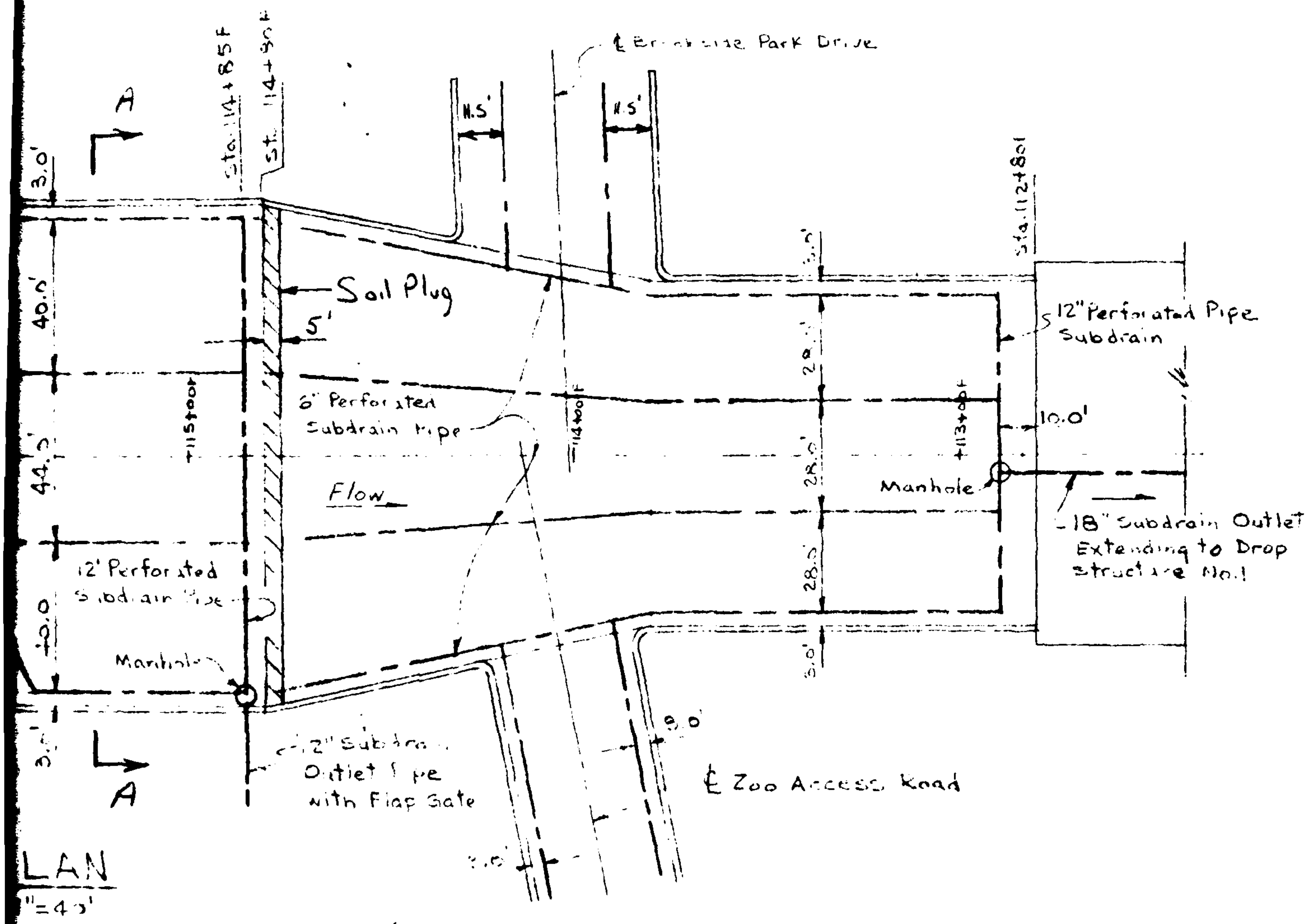
Although a subdrainage system may not be required to relieve uplift from the normal water table, a system is needed to relieve uplift from a sudden drawdown condition.

BY FF DATE 2-14-79 SUBJECT CONCRETE CHUTE- TRANSITION AT UPSTREAM END OF PROJECT BIG CREEK FLOOD CONTROL PROJECT SHEET NO. OF

CHKD. BY [illegible] DATE 3/2/79 JOB NO.

[redacted]





PLAN
1"=40'

NOTE: Section A-A shown on next sheet.

BIG CREEK CONTROL PROJECT
CLEVELAND, OHIO

PLAN OF SUBDRAINAGE SYSTEM
FOR CHUTE/TRANSITION

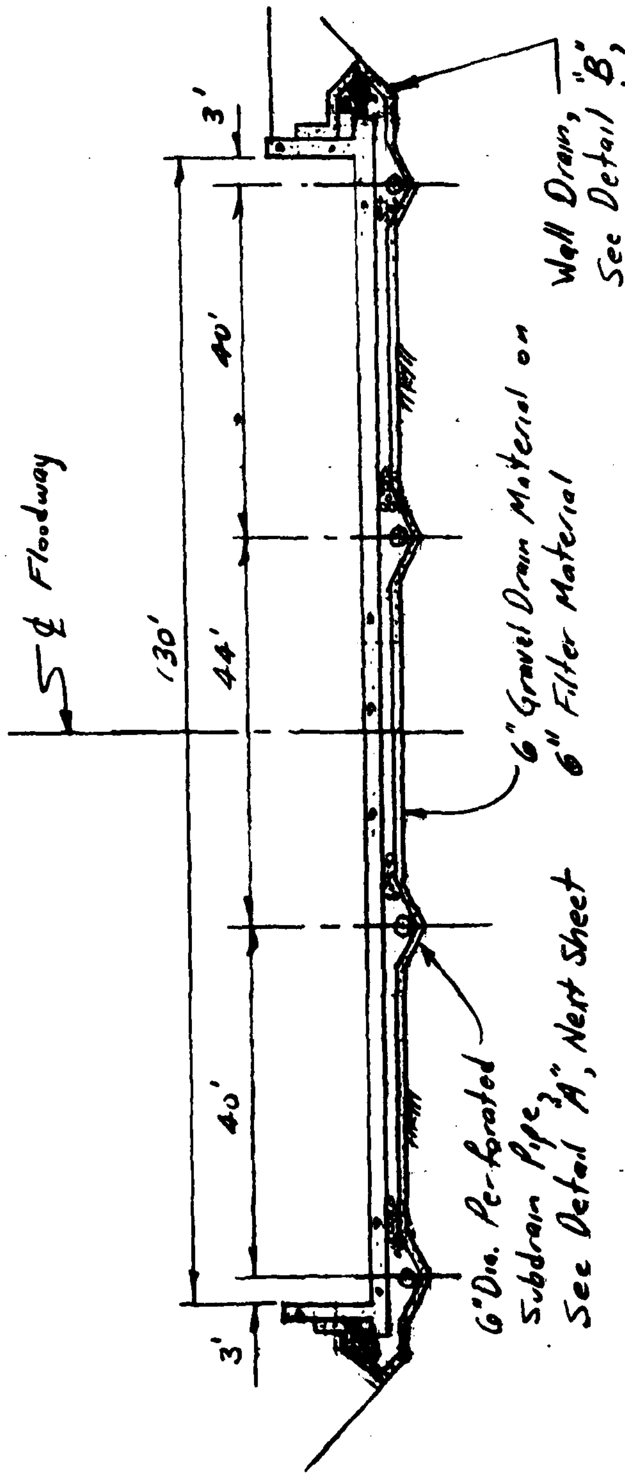
MARCH, 1979
DI-28

2

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT CHUTE-TRANSITION AT UPSTREAM END OF PROJECT FILE NO. ______
SHEET NO. ____ OF ____ SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FF DATE 2-14-79 CHECKED BY [illegible] DATE 3/2/79

SLAB AND SUBDRAINAGE SYSTEM



SECTION A-A
NOT TO SCALE

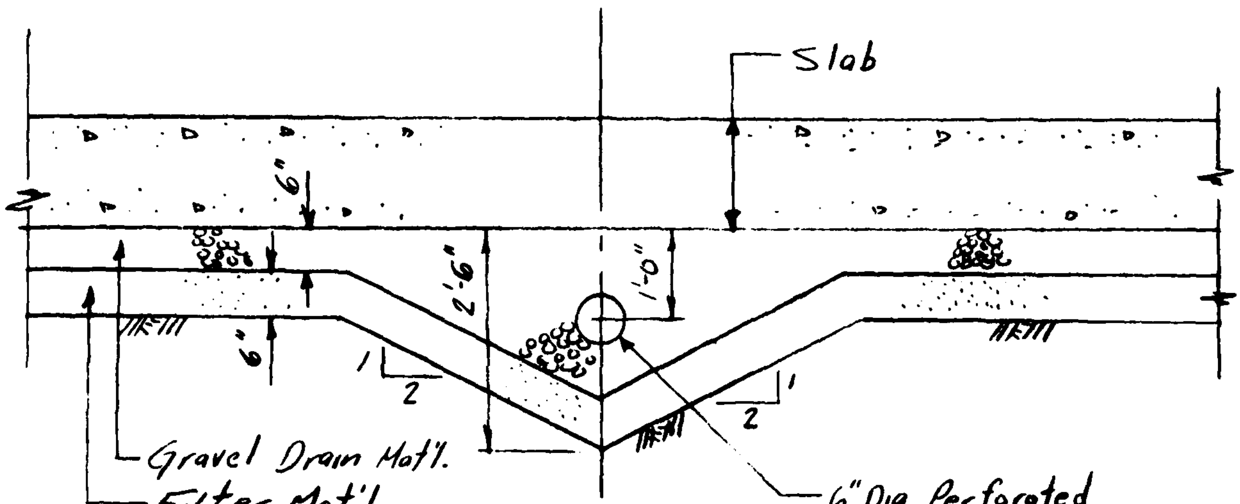
NOTE: Section A-A cut on previous sheet.

6819

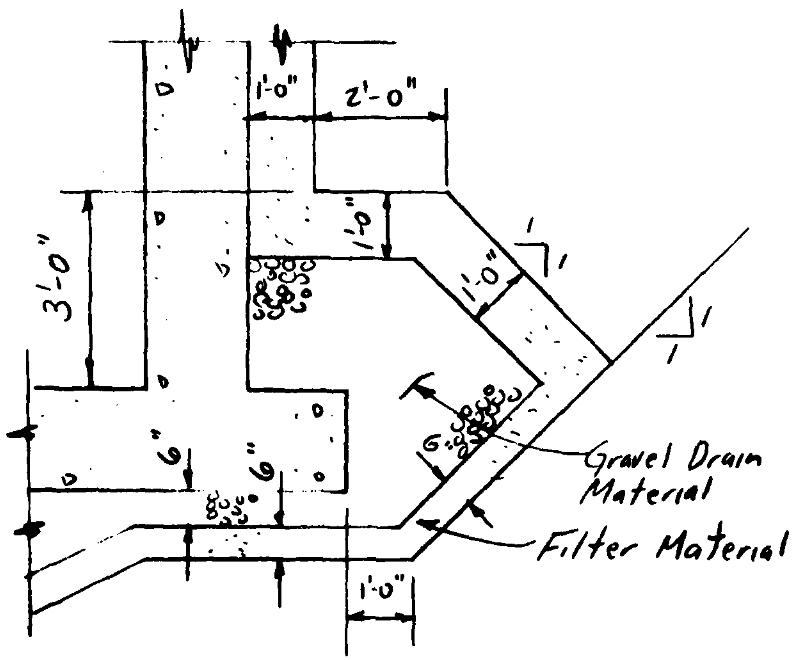
GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT CHUTE - TRANSITION AT UPSTREAM END OF PROJECT FILE NO. ______ SHEET NO. ______ OF ______ SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FF DATE 2-14-79 CHECKED BY AHW DATE 3/2/79

SLAB AND SUBDRAIN SYSTEM



DETAIL "A"
NOT TO SCALE



DETAIL "B"
NOT TO SCALE

D1-30

8313

SLAB AND SUBDRAINAGE SYSTEM

Slab Design

1. Compressive strength of concrete = 3,000 psi @ 28 days.
2. Grade 40 reinforcing steel.
3. An excerpt from ETL 1110-2-236 is as follows:
   "For U-channels, the minimum thickness of the wall and invert slab should not be less than 10" and preferably 12". Other retangular shaped channels should also have a minimum thickness of wall and footing of 12"."

   Base on this, the absolute minimum thickness of the slab is 12".
4. Consideration should be given to the following:
   a. The chute/transition will be used as a roadway for John Nagy Boulevard.
   b. A reach of the chute has an 8.7% slope with supercritical velocities.
   c. The downstream end of the chute acts as a combination transition & stilling basin.
   d. Although a subdrainage system is provided, the downstream end of the chute/transition has a zero percent slope which could possibly make the subdrainage system less than 100% effective; that is, there could possibly be uplift on the slab after a flood. Because of this, a design criteria established for the slab is that it should be able to resist a uniform uplift equal to a 3-foot hydrostatic head.

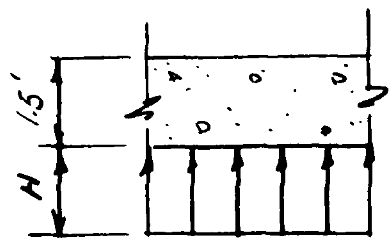
Slab Design - Cont'd.

e. Because of the openings in the walls at Brookside Park Drive and the Access to the Zoo, the hydraulic performance is uncertain at this part of the chute / transition.

f. Salt and cinders will probably be placed on John Nagy Boulevard in the winter.

5. Considering the items outlined above, it is believed that a conservative design is warranted, and an 18" thick slab is selected.

6. Uplift.



$62.5\,H = 1.5 \times 150$

$H = 1.5 \times 150/62.5$

$H = 3.6'$

The slab can take an uplift of 3.6'. This is greater than 3.0 ∴ O.K.

7. Steel Reinforcement for Temperature & Shrinkage

From EM 1110-2-2103, Paragraph 10b (1), temperature and shrinkage reinforcement = 0.20 % + 0.25 % for slabs exposed to weather = 0.25%. This is 0.25% of gross cross-sectional area with half in each face.

$.0025 \times 1.5 \times 144 = 0.54\ IN^2/FOOT$

$\frac{1}{2} \times 0.54 = 0.27\ IN^2/FOOT$ TOP & BOTTOM.

Use #5 @ 12 Top & Bottom (A_s = 0.31 IN.²/FT.)

Slab Design - Cont'd.

8. Joints

ETL 1110-2-236, Paragraph 6b, recommends continuously reinforced concrete. This would be practical for a long paved concrete channel, but it is not believed to be practical for the chute / transition structure on the Big Creek Project. Generally, the transverse joints (normal to flow) in the slab will be the same as the joints in the walls. EM 1110-2-2502, Paragraph 9b, states that "It has been demonstrated that, to be most effective, the contraction joints generally should be spaced not more than 30 feet apart.

A transverse joint spacing of 25 feet will be used for walls and slab. Longitudional joints (parallel to flow) will have to vary to fit the geometry but will not be greater than 30 feet.

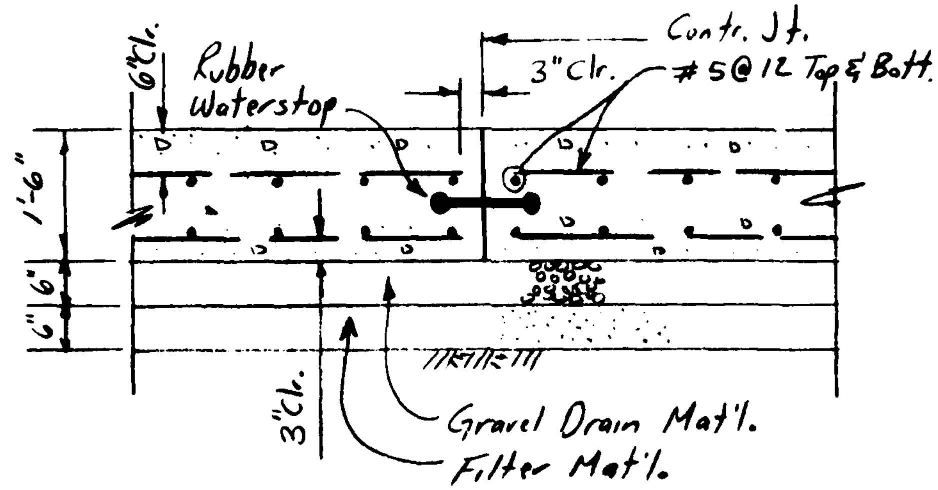
Slab Design - Cont'd.

9. Reinforcing Steel Clearance

From EM 1110-2-2103, Paragraph 8, a 6" clear cover is required for formed or screeded surfaces subject to high velocity flows such as ogee weirs and stilling basin slabs.

Because of supercritical velocities on the chute and because it will be used as a roadway for John Nagy Boulevard, a 6" cover is warranted for the top reinforcement.

A 3" clear cover is selected for bottom reinforcement.



CHUTE/TRANSITION SLAB

SLAB FOR ACCESS TO UNDERPASS AT BROOKSIDE PARK DRIVE

The slab section used for the chute/transition will also be used for the slab leading to the underpass. This is believed warranted because of the potential for uplift and because it is part of John Nagy Blvd.

SLAB FOR ZOO ACCESS ROAD

A reduction in slab thickness is believed to be warranted for the Zoo Access Road. The road will not be used frequently, and because it is on a 12% grade the potential for uplift is not great — the subdrainage system should function properly. Clearance requirements for reinforcement is not as great as for the chute/transition and 4" Clr. will be used for top steel.

A 15" slab is selected.
Uplift : $H = 1.25 \times 150/62.5 = 3.0'$
The slab can resist an uplift of $3.0'$ ∴ O.K.

Steel Reinforcement: $.0025 \times 1.25 \times 144 = A_s$
$A_s = 0.45\ IN^2/FOOT$
$0.225\ IN^2/FOOT$ Top & Bottom

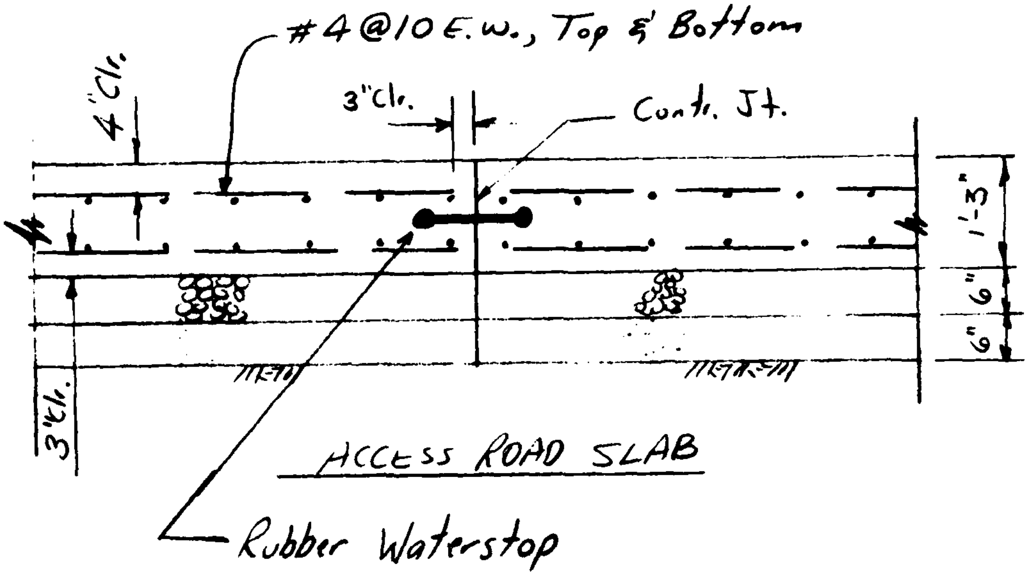
Use #4 @10 Top & Bottom

($A_s = 0.24\ IN.^2/FOOT$)

6813

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT: CHUTE - TRANSITION AT UPSTREAM END OF PROJECT FILE NO. ____
SHEET NO. ____ OF ____ SHEETS
FOR: BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY: FF DATE: 2-14-79 CHECKED BY: [illegible] DATE: 3/2/79



ACCESS ROAD SLAB

6313

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HARRISBURG, PA.

SUBJECT ________ FILE NO. ________
________ SHEET NO. ____ OF ____ SHEETS
FOR ________
COMPUTED BY ________ DATE ________ CHECKED BY ________ DATE ________

BIG CREEK FLOOD CONTROL PROJECT

STRUCTURAL DESIGN

CONCRETE TRANSITION AT END OF THREE-BARREL CONDUIT

6813

LOADING CONDITION FOR L-WALLS

Sudden Drawdown Condition

1. Water in transition at channel grade.
2. Backfill 6 inches below top of wall.
3. Backfill submerged to an elevation midway between the design water surface and channel grade (corresponds to the assumption of a 50% effective drainage system).
4. Backfill above the level of submergence naturally drained.
5. Lateral earth pressure from backfill based on an at-rest pressure coefficient ($K_r = 0.60$).
6. Uplift uniform across the base (pressure equal to reduced hydrostatic head in backfill).

UPLIFT CONDITION FOR MIDDLE SLAB

Slab designed to resist a uniform uplift based on the head from the sudden drawdown condition. (Uplift same as 6, above).

STABILITY CRITERIA FOR L-WALLS

1. Resultant shall be within the middle half of the base.

2. Shear-friction factor of safety shall not be less than 4.

3. Maximum foundation pressure shall not exceed 10 kips per square foot.

SHEAR-FRICTION FACTOR OF SAFETY

Reference: ETL 1110-2-184, 25 February 1974, "Gravity Dam Design - Stability".

$$S_{s\text{-}f} = \frac{SA}{\Sigma H}$$

$S_{s\text{-}f}$ = Shear-friction safety factor
S = Unit shearing strength at zero normal load along failure plane (Use 200 psi)
ΣH = Sumation of horizontal forces.
A = Area of resistance.

8319

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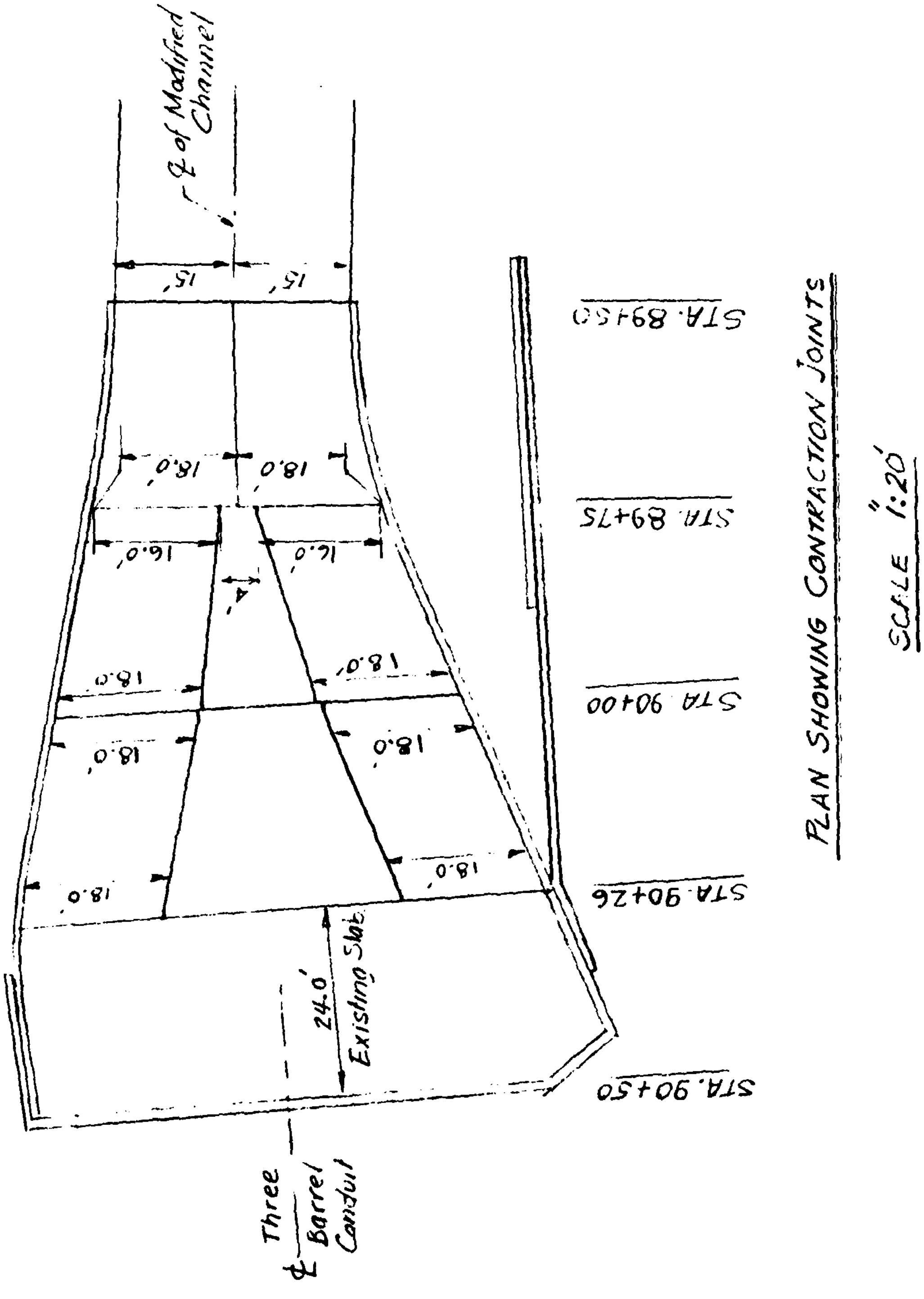
HARRISBURG, PA.

SUBJECT: CONCRETE TRANSITION AT END OF THREE BARREL CONDUIT
FILE NO. 7622
SHEET NO. 3 OF ____ SHEETS
FOR: BIG CR... FLOOD CONTROL PROJECT
COMPUTED BY: FEM DATE: 3-4-79 CHECKED BY: ____ DATE: ____



6919

UNIT WEIGHTS

Compacted Backfill, moist & saturated — 125 lb/ft^3
Compacted Backfill, submerged — 62.5
Concrete, Plain & Reinforced — 150
Water — 62.5

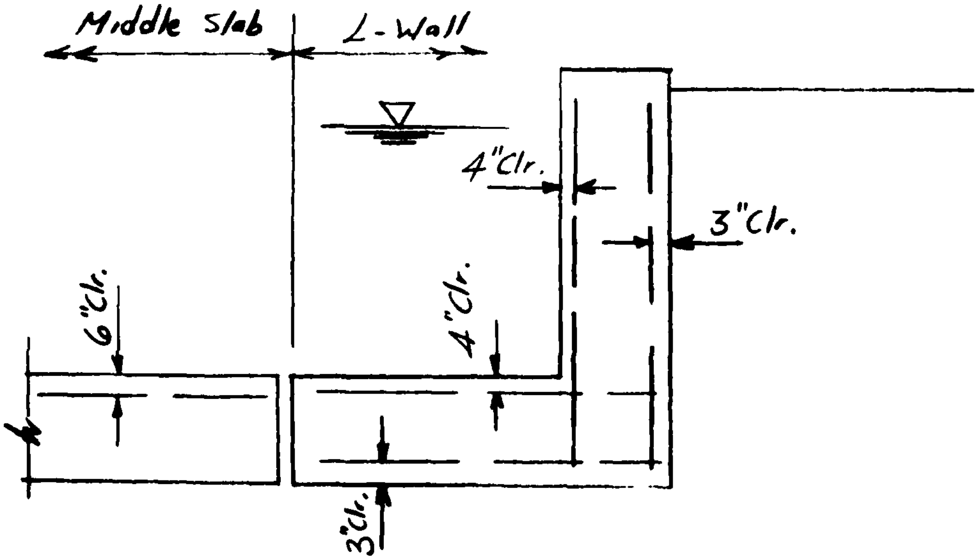
ALLOWABLE STRESSES

Reference: EM 1110-1-2102

f_c = 1,050 psi
f_s = 20,000 psi
n = 9.2

REINFORCING STEEL CLEARANCES

Reference: EM 1110-2-2103



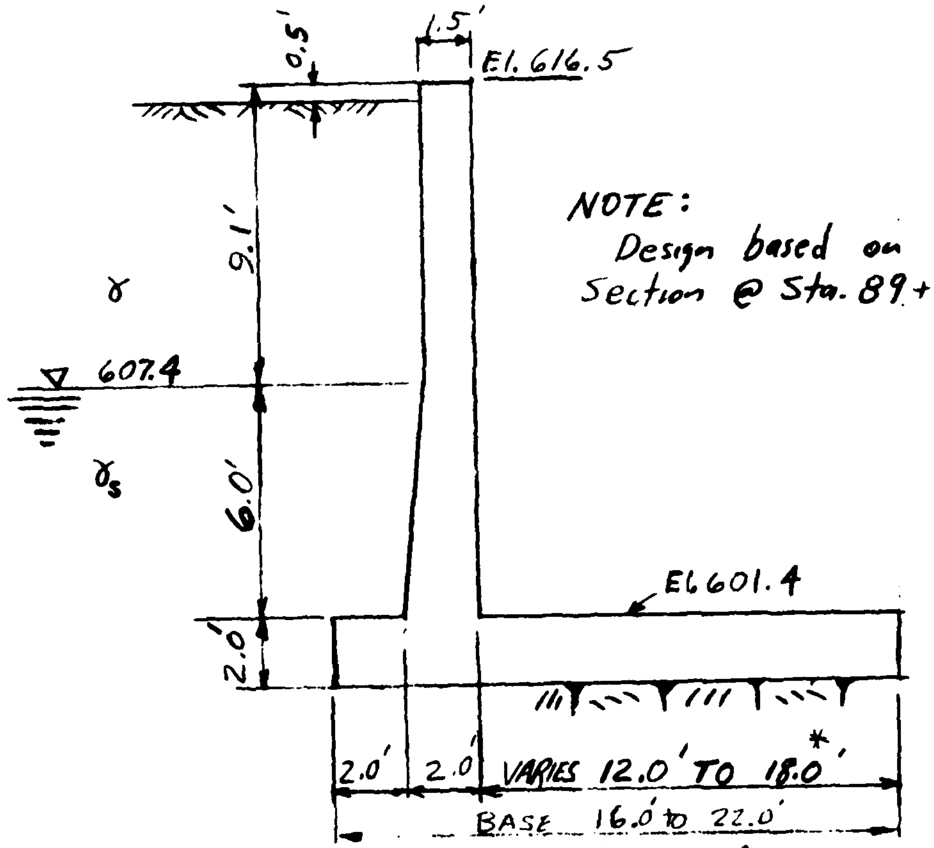
6919

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT CONCRETE TRANSITION AT END OF THREE BARREL CONDUIT FILE NO. 7622.00
SHEET NO. 5 OF ___ SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY WS DATE 2/29/79 CHECKED BY FFM DATE 3-4-79

TYPICAL SECTION

STATION	90+26M	90+00M	89+81.5M	89+75M	89+50M
GRADE	604.45	603.0	601.8	601.4	601.4
TOP OF WALL	616.5	616.5	616.5	616.5	616.5
WATER	613.4	613.4	613.4	613.4	613.4
BACKFILL	616.0	616.0	616.0	607.0	602.0



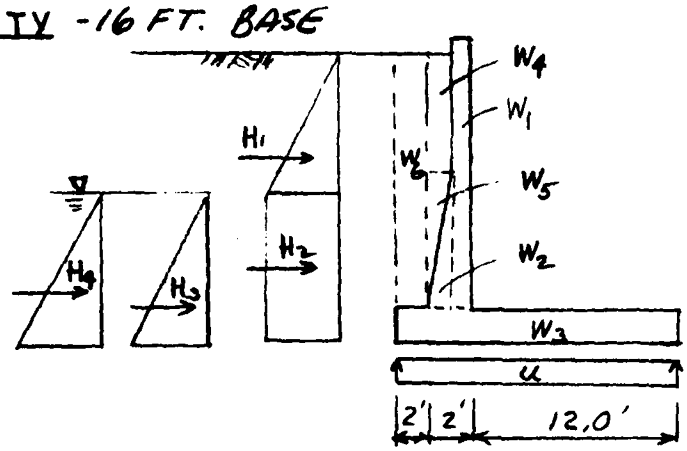
NOTE:
Design based on Section @ Sta. 89+50M

SECTION AT STA. 89+50M

* Final dimension will be within these limits; However its exact values will be shown on the contract drawings.

8819

STABILITY - 16 FT. BASE



	VERT.	HORIZ.	ARM	M_o (-)	M_R (+)
W_1 15.1 X 1.5 X .15	3.40		12.75		43.35
W_2 $\frac{1}{2}$ X 6 X .5 X .15	.23		13.67		3.14
W_3 2 X 16 X .15	4.8		8.0		38.40
W_4 8.6 X .5 X .125	.54		13.75		7.42
W_5 $\frac{1}{2}$ X .5 X 6 X .125	.19		13.83		2.63
W_6 14.6 X 2 X .125	3.65		15.0		54.75
H_1 $\frac{1}{2}$ X .125 X .6 X $\overline{8.6}^2$		2.77	11.27	31.22	
H_2 .125 X .6 X 8.6 X 8		5.16	4.0	20.64	
H_3 $\frac{1}{2}$ X .0625 X 8^2		2.00	2.67	5.34	
H_4 $\frac{1}{2}$ X .0625 X .6 X 8^2		1.20	3.04	3.65	
U 16 X 8.0 X .0625	- 8.0		8.0	64.0	
	4.81	11.13		124.85	149.69

$\Sigma M = 24.84$

$\frac{L}{4} = \frac{16}{4} = 4 \quad e_T = \frac{24.84}{4.81} = 5.16 > 4'$

Resultant within middle half, ∴ O.K.

$S_{s-f} = \frac{SA}{\Sigma H} = \frac{.200 \times 16 \times 144}{11.13} = 41.4 > 4$, ∴ O.K.

$f_p = \frac{2 \Sigma V}{3 e_T}^{*} = \frac{2}{3} \times \frac{4.81}{5.16} = .62 < 10$ KSF , ∴ O.K.

* See Page D1-43a

8913

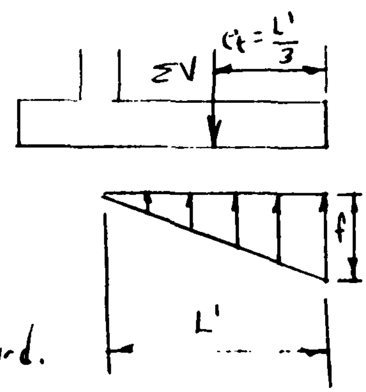
Discussion and Reference of Formula: $f_p = \frac{2\Sigma V}{3 e_t}$

References:

(1) Foundation Analysis and Design by Joseph E. Bowles, McGraw-Hill, 1972, Page 257.
(2) Foundation Engineering by Peck, Hanson and Thornburn, John Wiley, 1953, Page 327.
(3) Design of Concrete Structures by G. Winter and A.H. Nilson, McGraw-Hill, 1972, Page 307.

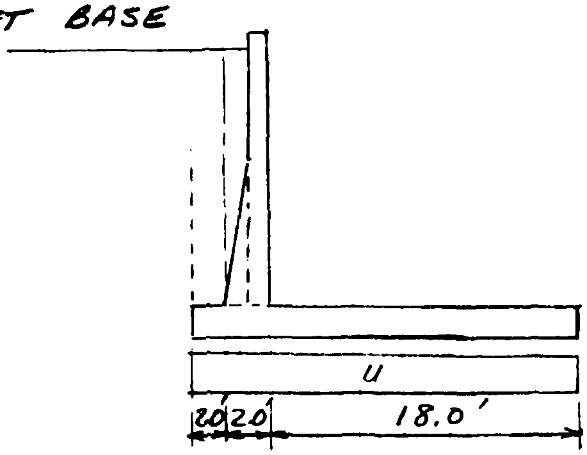
The formula f_p or $f = \frac{2\Sigma V}{3 e_t}$ is only applicable when the resultant falls outside the middle third, i.e. stress distribution is triangular.

ΣV = Total vertical force
e_t = Distance of resultant from toe = $L'/3$
$\therefore 3e_t = L'$
$\Sigma V = \frac{1}{2} f L'$
$2\Sigma V = f L' = f \times 3e_t$
$\therefore f = \frac{2}{3}\frac{\Sigma V}{e_t}$



NOTE: The formula used on Page D1-11 and D1-44 is used for trapezoidal stress distribution i.e. when resultant within middle third.

STABILITY - 22 FT BASE



	VERT.	HORIZ.	ARM	M_o (-)	M_R (+)
W_1	3.40		18.75		63.75
W_2	.23		19.67		4.52
W_3 22 X 2 X .150	6.6		11.0		72.60
W_4	.54		19.75		10.67
W_5	.19		19.83		3.77
W_6	3.65		21.0		76.65
H_1				31.22	
H_2				20.64	
H_3				5.34	
H_4				3.65	
U 22 X 8 X .0625	-11.0		11	121.0	
	3.61	11.13		181.85	231.96

$\Sigma M = 50.11$

$\frac{L}{4} = 5.50 \qquad e_T = \frac{\Sigma M}{\Sigma V} = \frac{50.11}{3.61} = 13.88 < 16.50$

$\frac{3}{4}L = 16.50$

Resultant within middle half, ∴ O.K.

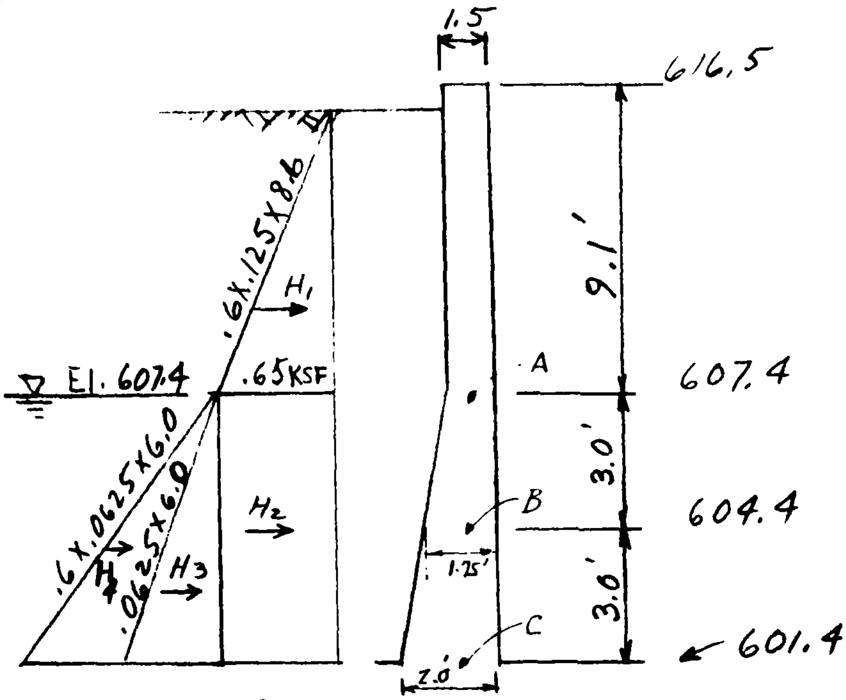
$$S_{s-f} = \frac{sA}{\Sigma H} = \frac{.200 \times 22 \times 144}{11.13} = 56.93 > 4, \therefore \text{O.K.}$$

$$f_p = \frac{\Sigma V}{L}\left[1 \pm \frac{6(L/2 - e_T)}{L}\right] = \frac{3.61}{22}\left[1 - \frac{6(11-13.88)}{22}\right] = .29 \text{ KSF}, \ .03 \text{ KSF}$$

$f_p < 10$ KSF, ∴ O.K.

8919

WALL DESIGN



$M_A = \frac{1}{2}(.6).125(8.6)^3 .38 = 9.06\ ^{'K}/_1$

$N_A = 1.5 \times 9.1 \times .150 = 2.05^K$

$M_B = \frac{1}{2}(.65)8.6(3+.38 \times 8.6) + .65 \times \frac{3^2}{2} + \frac{.0625 \times 3^2}{2} + \frac{.6 \times .0625 \times 3^3 \times .38}{2}$

$M_B = 20.91\ ^{'K}/_1$

$N_B = \left(12.1 \times 1.5 + \frac{.25 \times 3}{2}\right).15 + \left(\frac{.25 \times 3}{2} + .25 \times 8.6\right).125 = 3.09$

$M_C = \frac{.65 \times 8.6}{2}(6+.38 \times 8.6) + .65 \times \frac{6^2}{2} + \frac{.0625 \times 6^3}{2 \times 3} + \frac{.6 \times .0625 \times 6^3 \times .38}{2}$

$M_C = 41.39\ ^{'K}/_1$

$N_C = \left(15.1 \times 1.5 + .5 \times \frac{6}{2}\right).15 + \left(.5 \times \frac{6}{2} + .5 \times 8.6\right).125 = 4.35^K$

8319

WALL DESIGN *

POINT A $\qquad M = 9.06 \quad N = 2.05$

$$F = \frac{bd^2}{12000} = \frac{12\,(14.5)^2}{12,000} = 0.21$$

$$M = 9.06$$

$$KF = 152 \times .21 = \underline{31.96}$$

No A_s'

$$e = \frac{12 \times 9.06}{2.05} + 5.5 = 58.53 \quad E = 4.88$$

$$e/d = \frac{58.53}{14.5} = 4.03 \quad j = .89 \quad i = 1.29$$

$$a = 1.48$$

$$A_s = \frac{NE}{a\,d\,i} = 0.36$$

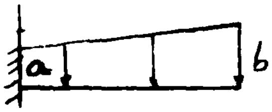
POINT	A	B	C
M K-FT.	9.06	20.09	41.39
N K	2.05	3.09	4.35
t IN.	18	21	24
d IN.	14.5	17.5	20.5
KF	31.96	46.51	63.84
e	58.53	85.53	122.68
NE	10.00	21.88	44.47
i	1.29	1.22	1.17
A_s	.36	.69	1.25

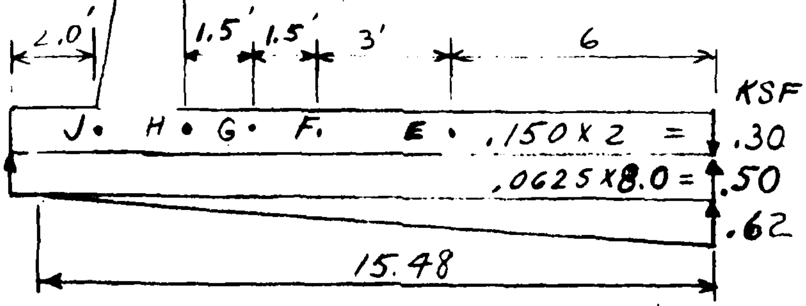
* Design based on use of ACI SP-3, Reinforced Concrete Design Handbook - Working Stress Design. For terminology see Page D1-22a.

8819

FOOTING DESIGN - 16 FT. BASE

$$M = \left| \frac{\ell^2}{6}(a+2b) \right|$$





		Mom. $\frac{K\text{-}FT}{FT.}$	$A_S^{*} = \frac{M}{1.48 \times 20.5}$
$M_E =$	$\frac{6^2}{6}(.580 + 2 \times .82)$	$= 13.32$	$.44$ IN²
$M_F =$	$\frac{9^2}{6}(.460 + 2 \times .82)$	$= 28.36$	$.93$
$M_G =$	$\frac{\overline{10.5}^2}{6}(.399 + 2 \times .82)$	$= 37.50$	1.24
$M_H =$	$\frac{\overline{12}^2}{6}(.339 + 2 \times .82)$	$= 47.54$	1.57

$$M_J = (-3.65 + 2 \times .20) + \left(\tfrac{1}{2} \times .059 \times 1.48\right)\frac{1.48}{3} = -3.22 \ ^{K\text{-}FT}/_{FT}$$

$$V = \frac{.82 + .339}{2} \times 12 = 6.954^K$$

$$v = \frac{6{,}954}{12 \times 20.5} = 28 \text{ psi} < 60 \text{ psi}$$

O.K. @ Face ∴ O.K @ $d/2$

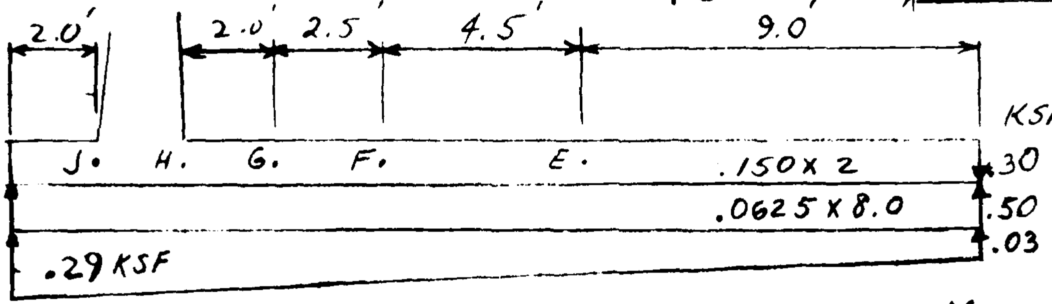
* The effect of normal forces is neglected in computing "A_S"

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT CONCRETE TRANSITION AT END OF THREE BARREL CONDUIT FILE NO. 7622.00
SHEET NO. 11 OF ____ SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY WS DATE 2/27/79 CHECKED BY FFM DATE 3-4-79

FOOTING DESIGN - 22 FT. BASE

$$M = \left|\frac{\ell^2}{6}(2a+b)\right|$$



K-FT/FT.

$$A_S^{*} = \frac{M}{1.48 \times 20.5} \quad \text{IN}^2$$

$$M_E = \frac{9^2}{6}(2 \times .336 + .23) = 12.18 \qquad .40$$

$$M_F = \frac{\overline{13.5}^2}{6}(2 \times .389 + .23) = 30.62 \qquad 1.00$$

$$M_G = \frac{\overline{16}^2}{6}(2 \times .419 + .23) = 45.57 \qquad 1.50$$

$$M_H = \frac{\overline{18}^2}{6}(2 \times .442 + .23) = 60.16 \qquad 1.98$$

$$M_J = -3.65 + \frac{2^2}{6}(.436 + 2 \times .49) = -2.71 \ \text{K-FT/FT.}$$

$$V = \frac{.442 + .23}{2} \times 18 = 6.048^{K}$$

$$V = \frac{6048}{12 \times 20.5} = 24.6 \text{ psi} < 60 \text{ psi}$$

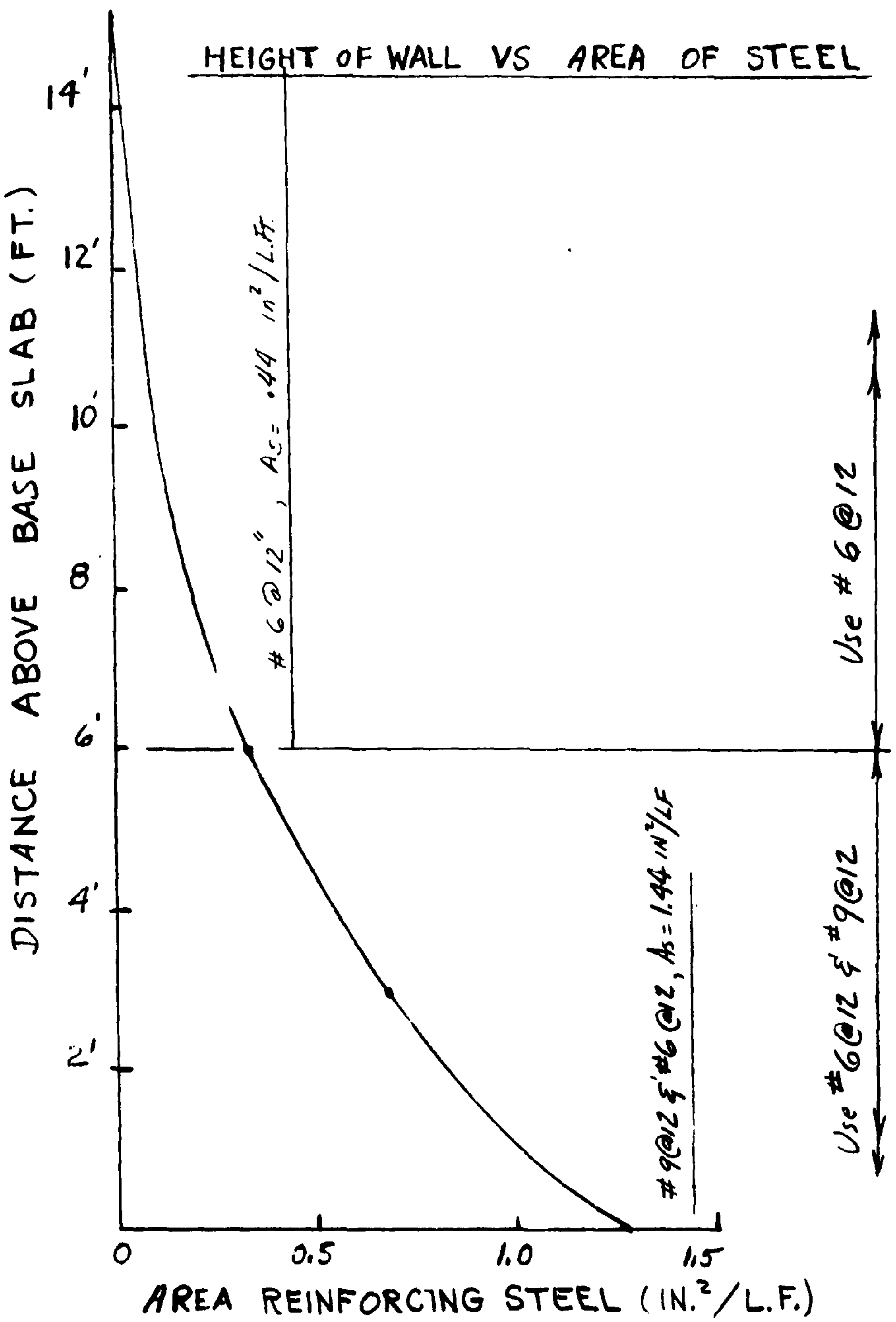
O.K @ Face ∴ O.K @ d/2

* The effect of normal forces is neglected in computing "A_s"

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT CONCRETE TRANSITION AT END OF THREE BARREL CONDUIT FILE NO. 7622.00
SHEET NO. 12 OF ___ SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY WS DATE 2/28/79 CHECKED BY FFM DATE 3-4-79

HEIGHT OF WALL VS AREA OF STEEL



6813

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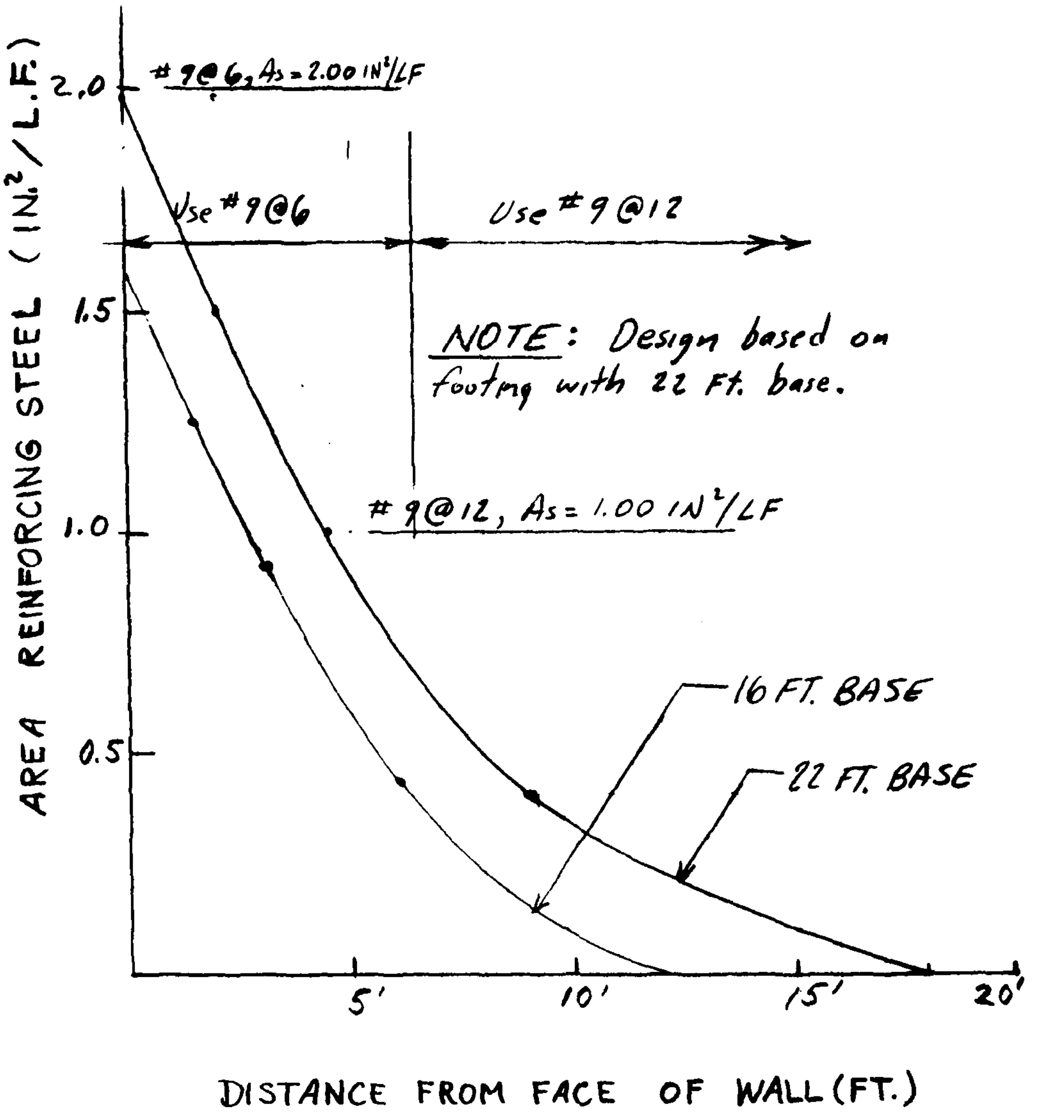
HARRISBURG, PA.

SUBJECT CONCRETE TRANSITION AT END OF THREE BARREL CONDUIT FILE NO. 7622.00
SHEET NO. 13 OF ____ SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY WS DATE 2/28/79 CHECKED BY FFM DATE 3-4-79



AREA OF FOOTING REINFORCING STEEL
VS
DISTANCE FROM FACE OF WALL

6313

Temperature & Shrinkage Reinforcement for L-Walls

Reference: EM 1110-2-2103 21 May 1971, "Details of Reinforcement-Hydraulic Structures".

For the stem, Paragraph 10 b (1) is applicable. Cleveland is considered to be in a region with severe climatic temperature conditions and 25 % will be added to the 0.20 % of gross area.

$0.20\% \times 1.25 = 0.25\%$

$A_s = 0.0025 \times$ gross cross-sectional area, half in each face, with a maximum of #6 @12.

For Stem thickness $(t) = 1.5'$

$A_s = 0.0025 \times 1.5 \times 144 = 0.54 \text{ IN}^2/\text{FT.}$

$A_s = 0.27 \text{ IN}^2/\text{FT.}$ in each face.

Use #5 @ 12 ($A_s = 0.31 \text{ IN}^2/\text{FT}$).(Horiz. & Vert.)

For Stem thickness $(t) = 2.0'$

$A_s = 0.0025 \times 2.0 \times 144 = 0.72 \text{ IN}^2/\text{FT.}$

$A_s = 0.36 \text{ IN}^2/\text{FT.}$ in each face

Use #5 @ 10 ($A_s = 0.37 \text{ IN}^2/\text{FT}$) (Horiz.)

Use #6 @12 ($A_s = 0.44$) (Vertical)

For the slab of the L-wall, Paragraph 10 b (2) is applicable. As above, add 25%.

$A_s = 0.20\% \times 1.25 = 0.25\%$ of gross area

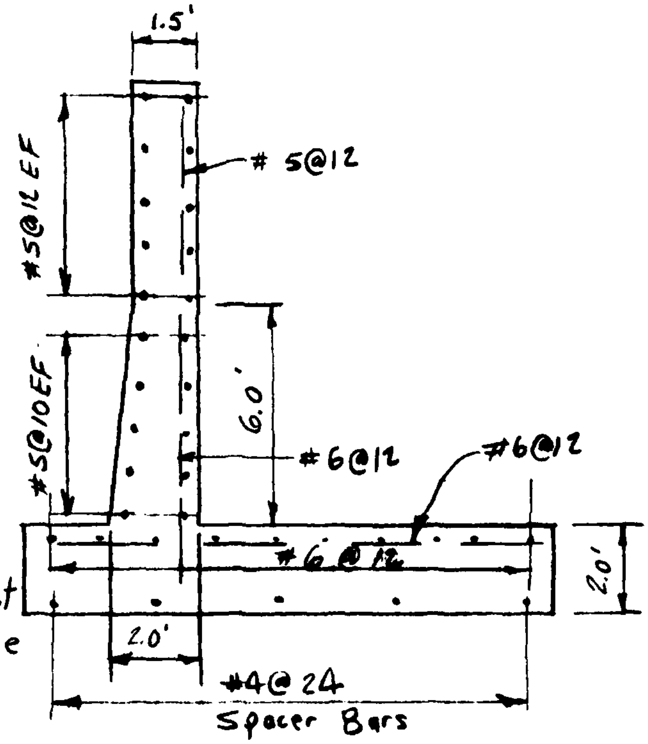
$A_s = 0.0025 \times$ gross cross-sectional area, half in each direction in the opposite face (top), with a maximum of #6 @ 12. No reinforcement is required in the restrained face (bottom); however, #4 @ 24 spacer bars will be provided (See Note Page 01-52).

Slab of the L-wall - Cont'd.

$A_s = 0.0025 \times 2.0 \times 144 = 0.72\ IN^2/FT$
$A_s = 0.36\ IN^2/FT$ in each direction
Use #6 @ 12 ($A_s = 0.44\ IN^2/FT.$) *

Main steel will govern for steel normal to wall but shall not be less than #6 @ 12.

* #5 @ 10 ($A_s = 0.37$) would satisfy requirement; however, #6 @ 12 is selected as a conservative design since no reinforcement in bottom (other than spacer bars).



L-Wall

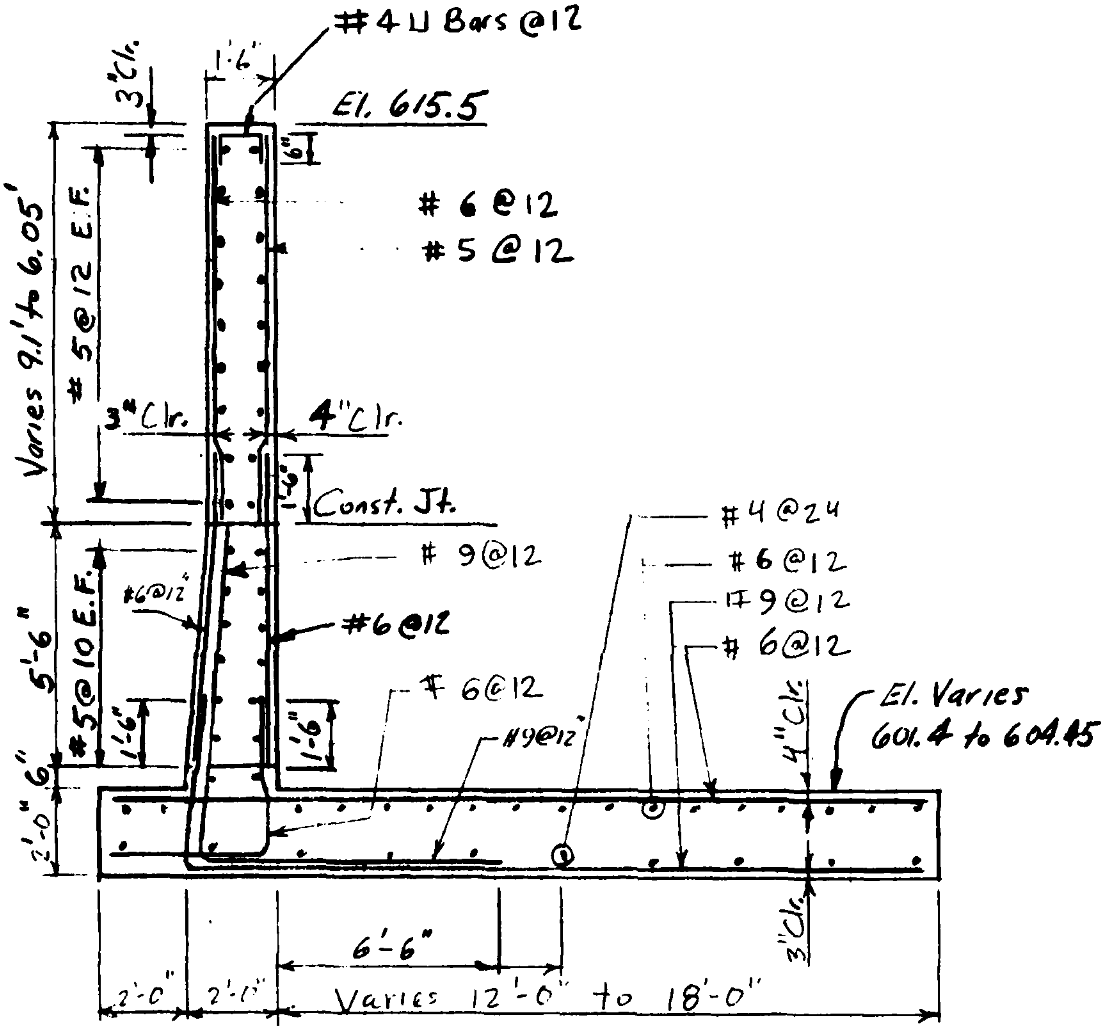
NOTE:
Spacer bars are needed for the main reinforcement at bottom of slab. Size and spacing selected based on engineering judgement. Size and spacing is not considered to be excessive. This size and spacing has been used on similiar hydraulic structures.

Temperature & Shrinkage Reinforcement

6313

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT CONCRETE TRANSITION AT END OF THREE - BARREL CONDUIT FILE NO. 1622.00
SHEET NO. 16 OF ___ SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY WES DATE ___ CHECKED BY FFM DATE 3-4-79



TYPICAL WALL SECTION

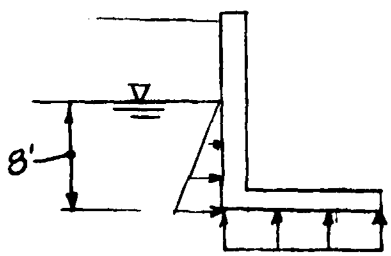
Scale: 1/4" = 1'-0"

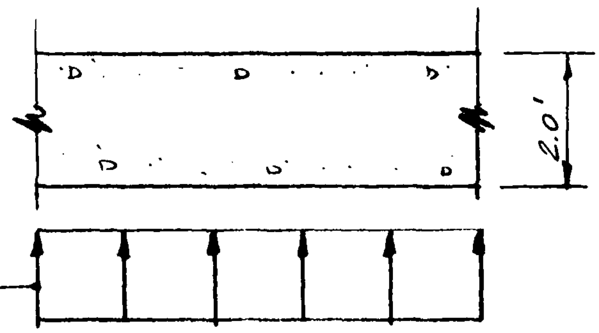
8819

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT: CONCRETE TRANSITION AT END OF THREE BARREL CONDUIT — FILE NO. 7622 — SHEET NO. 17 OF ___ SHEETS
FOR: BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY: FF — DATE: 2-26-79 — CHECKED BY: FFM — DATE: 3-4-79

Middle Slab Design





Uplift from sudden drawdown equal to 8.0' head

$$\text{Wt. Concrete} = 2.0' \times 1.0' \times 1.0' \times 150\ ^{LB}/_{FT^3} = 300\ ^{LB}/_{FT^2}$$

$$\text{Uplift} = 8.0 \times 62.5 = 500\ ^{LB}/_{FT^2}$$

$$\text{Uplift} - \text{Wt. Concrete} = 500 - 300 = 200\ ^{LB}/_{FT^2}$$

Anchor Bars needed to resist $200\ ^{LB}/_{FT^2}$ uplift. Use #11 Hooked Anchor Bar grouted in 3" Dia. drilled hole. Anchor Bars will extend 10' into rock. Check anchor bar strength for the following types of failures:

1. Bar failing in tension (Use $f_s = 20{,}000$ psi)
2. Bar & grout pulling out; that is bond failure between grout and rock (Use $\mu = 90$ psi)
3. Bar pulls out; that is bond failure between grout and bar (Use $\mu = 140$ psi)
4. Hooke pulling out.

Anchor Bar Strength for 1 $= f_s A_s = 20{,}000 \times 1.56 = 31{,}200\#$ ←

Anchor Bar Strength for 2 $= L \times C \times \mu = (10 \times 12) \times D\pi \times 90 = 120 \times 3.0\pi \times 90 = 101{,}790\#$ ←

6313

Middle Slab Design - Cont'd.

Bar strength for 3 = $L \times P \times \mu$
$= 10 \times 12 \times 4.430 \times 140$
$= 74{,}420^{\#}$

Bar strength for 4
From ACI-318-77, Para. 12.5

$f_h = \xi \sqrt{f'_c} = 360\sqrt{3000} = 19{,}718$ psi
Strength $= 19{,}718 \times 1.56 = 30{,}760^{\#}$

Hooke of anchor bar will be hooked over slab reinforcing steel so strength actually more.

For design purposes, use Anchor Bar Strength $= 30{,}000^{\#}$

Anchor Bar Spacing: Area $= 30000^{\#} / 200^{\#}/\text{FT}^2$
$= 150\ \text{FT}^2$

∴ One anchor bar needed per 150 ft^2 of slab.

As a minimum, place anchor bars @ about 10' cc or one per 100 ft^2.

8818

Middle Slab Design - Cont'd.

Temperature & Shrinkage Reinforcement

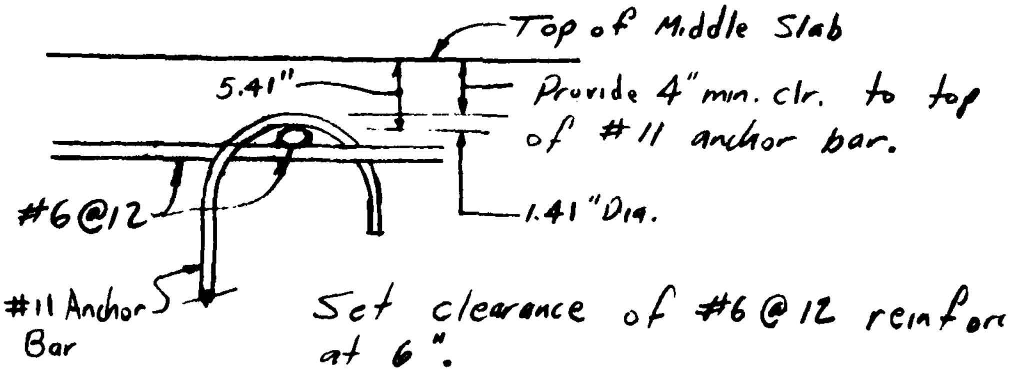
Para. 16b(2) of EM 1110-2-2103 is applicable for the slab. Same as for slab of L-wall.

$A_s = 0.0025 \times 2.0 \times 144 = 0.72\ IN^2/FT$

$A_s = 0.36\ IN^2/FT$ in each direction top of slab only.

No reinforcement is required in restrained face (bottom).

Use #6 @ 12 EW ($A_s = 0.44\ IN^2/FT$).



Set clearance of #6 @ 12 reinforcement at 6".

8313

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT ______ FILE NO. ______
______ SHEET NO. ____ OF ____ SHEETS
FOR ______
COMPUTED BY ______ DATE ______ CHECKED BY ______ DATE ______

BIG CREEK FLOOD CONTROL PROJECT

STRUCTURAL DESIGN

CONCRETE FLUME AND RETAINING
WALLS AT WEST 25TH ST. BRIDGE

6919

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel Flume FILE NO. 7622
SHEET NO. 1 OF 12 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY EFM DATE 3-5-79 CHECKED BY PwGG DATE 3/5/79

The diversion channel flume is designed as an integral U-shape frame. Since the hights of its walls are not costant. The flume has been designed for Two different cross-section. For ecconomy and convenience, the whole flume will consist of the following:

1- Reach "A":

- from Sta. 69+72 to Sta. 68+54

Section "A" for Left half & Right half.

2. Reach "B":

from Sta. 68+54 to Sta. 68+02

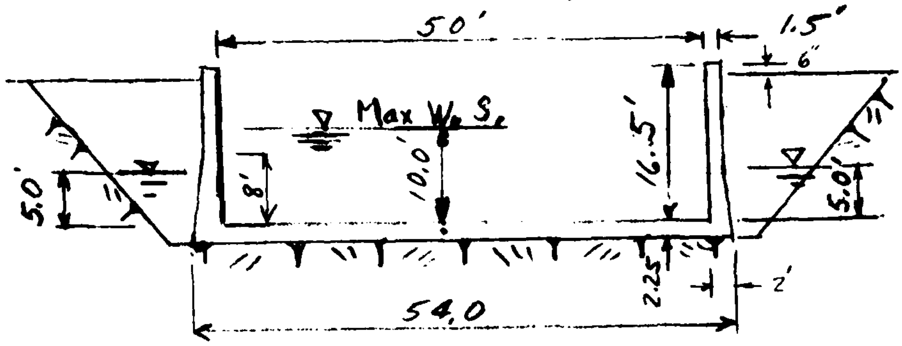
Section "B" for left half, Sec. "A" for Right half.

3- Reach "C":

from Sta. 68+02 to Sta. 67+74

Sec "B" for Left half & Right half.

8319



SECTION "A"

Loading Criteria - sudden drawdown

Flume Empty
Hydrostatic head in backfill at elevation midway between flume grade and maximum water surface elevation.
$K_r = 0.6$
Backfill within .5 feet of top of wall
No surcharge loading

$$\begin{aligned}
* \rightarrow\ & 1.5 \times 16.5 \times .15 = 3.713 \\
+\ & 0.5 \times \tfrac{8.0}{2} \times .15 = 0.300 \\
+\ & 0.5 \times 8.0/2 \times .125 = 0.250 \\
+\ & 0.5 \times 8.0 \times .125 = 0.500 \\
& \overline{\quad 4.763}
\end{aligned}$$

Stability

Conc & Soil
$(2.25 \times 54).15 + 2 \times 4.763^{*} = 27.75^K \downarrow$

Uplift
$54 \times .0625(5 + 2.25) = \underline{24.47}^K \uparrow$
$3.28^K \downarrow > 0.0$
∴ No Flotation

Pressure on foundation
$P = \frac{3.28}{54} = .060764$ KSF.

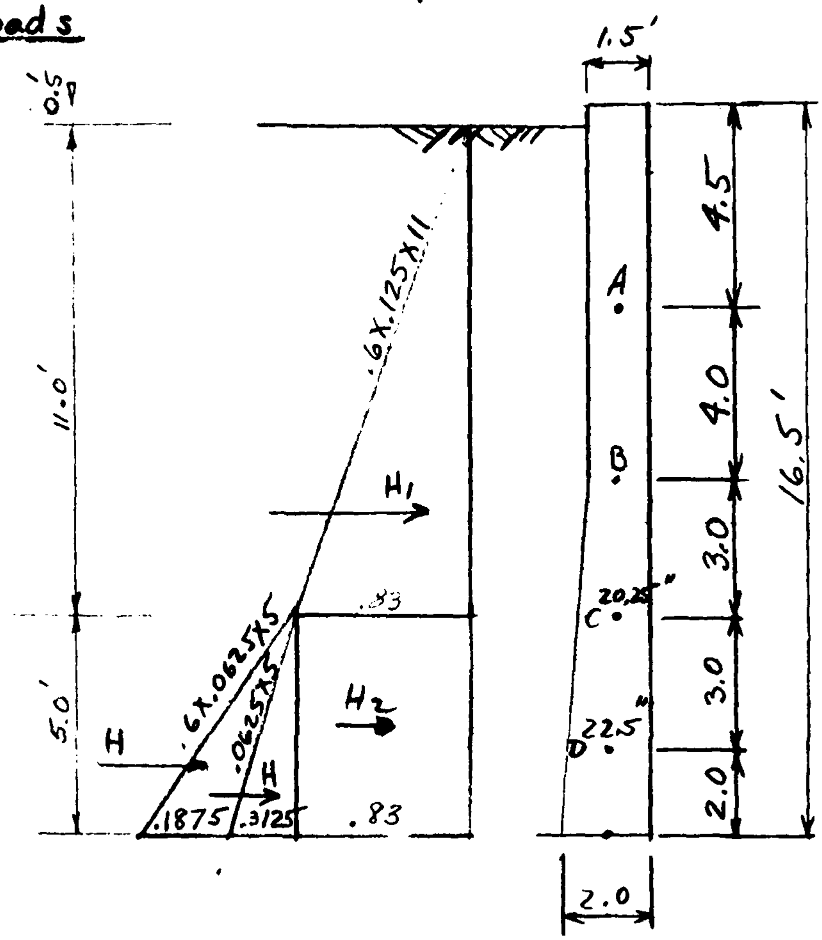
$\therefore P_s = .060764 + \frac{24.47}{54} = .513889$ KSF
Reaction on slab.

6819

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT DIVERSION CHANNEL FLUME FILE NO. 7622.00
SHEET NO. 2 OF 17 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY WS DATE 3/1/79 CHECKED BY FFM DATE 3-5-79

Moments & Loads



$$M_A = \frac{.6 \times .125 \times \overline{4.0}^3 \times .38}{2} = .91\ {}'^{K}/_{1}$$

$$M_B = \frac{.6 \times .125 \times 8^3 \times .38}{2} = 7.3\ {}'^{K}/_{1}$$

$$M_C = \frac{.6 \times .125 \times \overline{11}^3 \times .38}{2} = 18.97\ {}'^{K}/_{1}$$

$$M_D = \frac{.6 \times .125 \times 11^2}{2} \times 7.18 + \frac{.83 \times 3^2}{2} + \frac{.6 \times .0625 \times 3^3 \times .38}{2} + \frac{.0625 \times 3^2}{2}$$

$$M_D = 36.79\ {}'^{K}/_{1}$$

$$M_E = \frac{.6 \times .125 \times \overline{11}^2}{2} \times 9.18 + \frac{.83 \times 5^2}{2} + \frac{.6 \times .0625 \times 5^3 \times .38}{2} + \frac{.0625 \times 5^3}{2 \times 3} = 54.22^{K}$$

8919

Moments & Loads (Contd.)

POINT F

ITEM	DESCRIPTION	VERT	HORIZ.	ARM	MOM.
CONC.	1.5 X 16.5 X .15	3.71		.75	+ 2.78
	.5 X 8.0 X .15	.30		1.67	+ .50
	2.0 X 2.25 X .15	.68		1.00	+ .68
SOIL	.5 X 8 X .125	.5		1.75	+ .88
	.5 X 8/2 X .125	.25		1.83	+ .46
H_1	$11^2/2$ X 0.075		4.54	10.305	- 46.78
H_2	11 X 7.25 X .075		5.98	2.5	- 14.95
H_3	$7.25^2/2$ X .0375		.99	1.63	- 1.61
H_4	$7.25^2/2$ X .0625		1.64	1.2917	- 2.12
Found+U	0.513889 X 2.0	- 1.03		1.00	- 1.03
		4.41	13.15		- 61.19

$N_A = 4.5 \times 1.5 \times .15 = 1.01^K$

$N_B = 8.5 \times 1.5 \times .15 = 1.91$

$N_C = 11.5 \times 1.5 \times .15 + \frac{3.0}{2} \times \frac{2.25}{12}(.15 + .125) + \frac{2.25 \times 8 \times .125}{12}$

$N_C = 2.85^K$

$N_D = 14.5 \times 1.5 \times .15 + \frac{6 \times 4.5}{2 \times 12}(.15 + .125) + \frac{4.5 \times 8 \times .125}{12} = 3.95^K$

$N_E = \left(16.5 \times 1.5 + \frac{8 \times .5}{2}\right).15 + \left(8 \times .5 + \frac{8 \times .5}{2}\right).125 = 4.76^K$

6319

AD-A102 433 CORPS OF ENGINEERS BUFFALO NY BUFFALO DISTRICT F/G 13/2
BIG CREEK FLOOD CONTROL PROJECT, CLEVELAND, OHIO. PHASE II. GEN--ETC(U)
AUG 79

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2 OF 4
AD A
102433

Moments & Loads

Point G $M = M_F + [w(\text{found \& uplift}) - w(\text{concrete})]\, l^2/2 - V_F\, l$

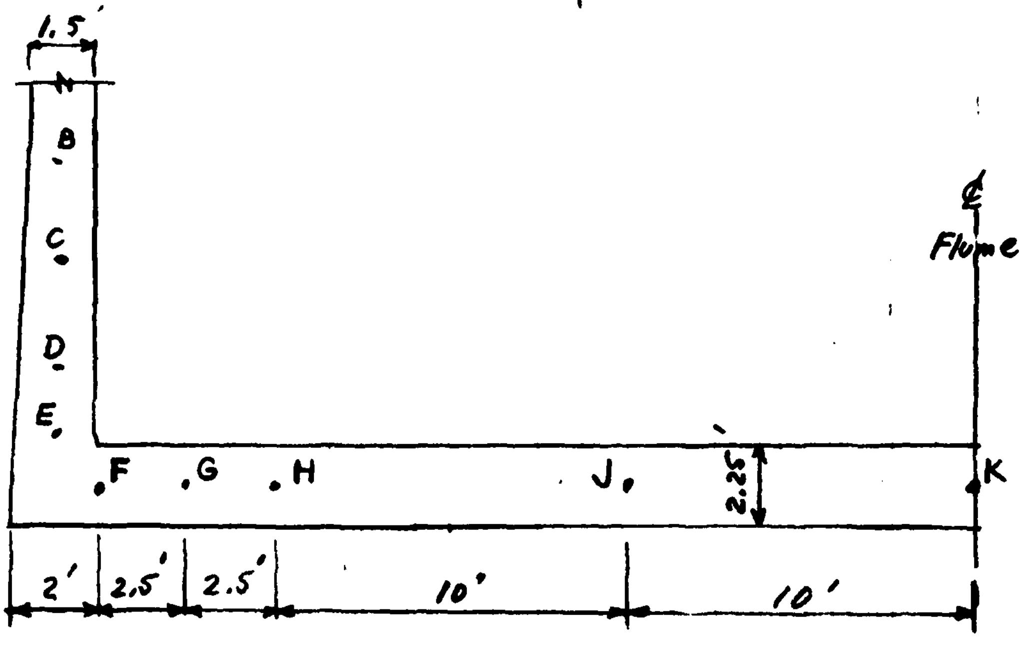
$M = 61.19 + (0.513889 - 2.25 \times 0.150) \times 2.5^2/2 - 4.41 \times 2.5 = 50.72$ kip-ft

Point H $M = 61.19 + 0.176389 \times 5.0^2/2 - 4.41 \times 5.0$
$M = 41.35$ k-ft

Point J $M = 61.19 + 0.176389 \times 15^2/2 - 4.41 \times 15.0$
$M = 14.89$ k-ft

Point K $M = 61.19 + 0.176389 \times 25.0^2/2 - 4.41 \times 25.0$
$M = 6.07$ k-ft

Points G to K $N = 13.15$ kips



8813

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel Flume FILE NO. 7622.00
SHEET NO. 5 OF 13 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 11/10/78 CHECKED BY WS DATE 1/19/79

Concrete Design *

f_s = 20.0 ksi   K = 152 ①
$f'c$ = 3.0 ksi   a = 1.48 ②
n = 9.2 f_c = 1.05 ksi

Concrete cover of reinforcing bars

Wall - soil side : 3"   water side : 3"
Slab - soil side : 4"   water side : 4"

* Design based on use of ACI SP-3 Handbook.
For terminology see Page DI-22a

① $K = \frac{f_c k j}{2}$, Where $k = \frac{1}{1 + f_s / n f_c}$, $j = 1 - 1/3 k$

K is used in equations :
$M \leq KF$; $F = \frac{bd^2}{12000}$
or $NE \leq KF$

② $a = \frac{f_s j}{12000}$, a is used in equations :
$A_s = \frac{M}{ad}$ or $A_s = \frac{NE}{adi}$
Where $i = \frac{1}{1 - j d/e}$

6819

Concrete Design, Point E, Base of Wall *

M = 54.22 k-ft
N = 4.76 kips
t = 24 inches
d = 20.5 inches
d'' = 8.5 inches

f_s = 20.0 ksi
f'_c = 3.0 ksi
f_c = 1.05 ksi
n = 9.2

a = 1.48
K = 152
j = 0.89
k = 0.326

$$e = \frac{12M}{N} + d'' = \frac{12 \times 54.22}{4.76} + 8.5 = 145.2$$

$$E = e/12 = 12.1$$

$$NE = 4.76 \times 11.99 = 57.60$$

$$KF = 152 \times \frac{20.5^2}{1000} = 63.88$$

NE − KF = —

$$e/d = \frac{145.20}{20.5} = 7.08$$

$$i = \frac{1}{1 - jd/e} = \frac{1}{1 - 0.89/7.02} = 1.15$$

$$A_s = \frac{NE}{adi} = \frac{57.60}{1.48 \times 20.5 \times 1.15} = 1.66\ \text{in}^2/\text{ft}$$

CHECK SHEAR : V = 1.325 Kips at base of wall.

$$v = V \times 1000/bd$$

$$v = \frac{1.325 \times 1000}{12 \times 20.5} = 58\ \text{psi} < 60\ \text{psi}$$

O.K. @ edge ∴ O.K @ d/2 from slab.

* Design based on use of ACI SP-3 Handbook. See Page 01-22a. Also, see Page 01-63.

6515

Concrete Design

fs = 20.0 ksi K = 152 4
fc = 1.05 ksi a = 1.48 5
n = 9.2 j = 0.89 6

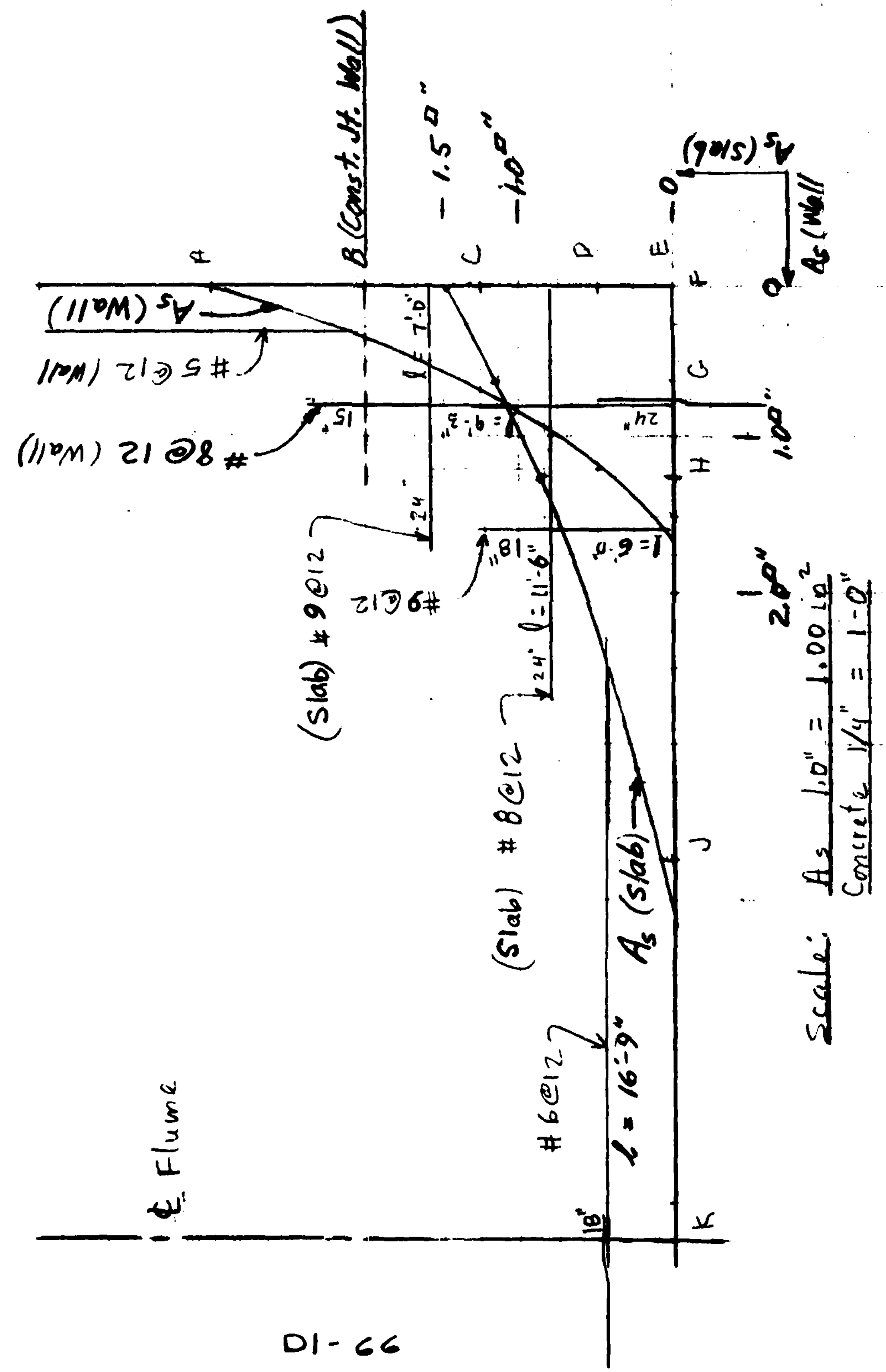
Point	A	B	C	D
Moment K-ft 0	0.91	7.30	18.97	36.79
Normal Kips 1	1.01	1.91	2.85	3.95
t inches 2	18.0	19.0	20.25	22.5
d inches 3	14.5	14.5	16.75	19.0
KF	31.96	31.96	42.64	54.87
c	16.3	51.36	86.50	119.52
NE	1.37	8.18	20.54	39.34
i	4.79	1.33	1.21	1.16
As	0.013	0.28	0.68	1.20

Point	F	G	H	J	K
Moment	61.19	50.72	41.35	14.89	6.07
Normal	13.15	13.15	13.15	13.15	13.15
t	27.0	27.0	27.0	27.0	27.0
d	22.5	22.5	22.5	22.5	22.5
KF	76.95	76.95	76.95	76.95	76.95
c	64.88	55.28	45.73	22.59	14.54
NE	71.05	60.00	51.21	29.75	15.93
i	1.45	1.56	1.75	8.8	—
As	1.47	1.16	0.88	0.08	—

8818

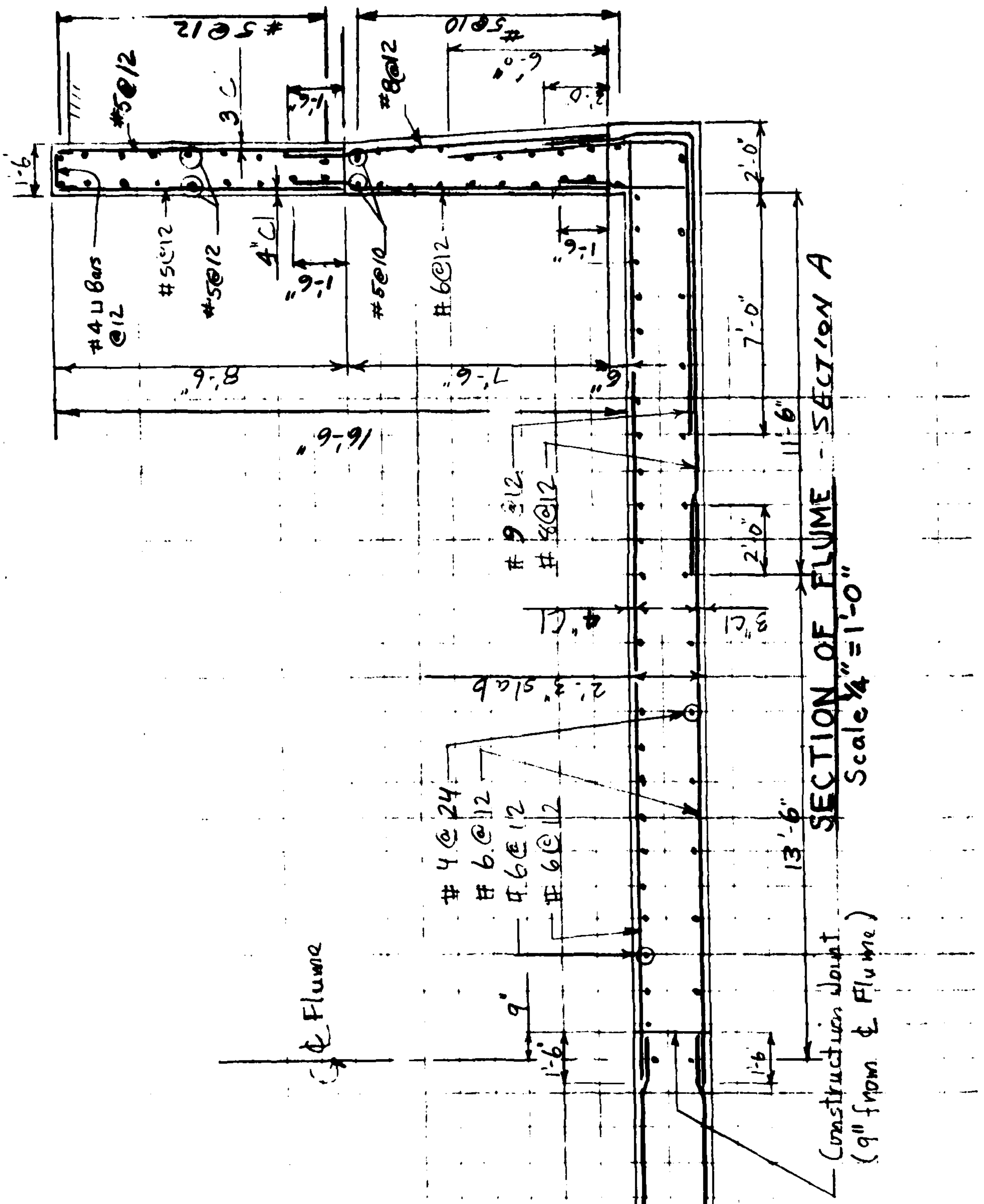
GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel Flume FILE NO. 7622.00
SHEET NO. 8 OF 13 SHEETS
FOR Big Creek
COMPUTED BY PvdG DATE 11/20/79 CHECKED BY WS DATE 1/23/79



DI-66

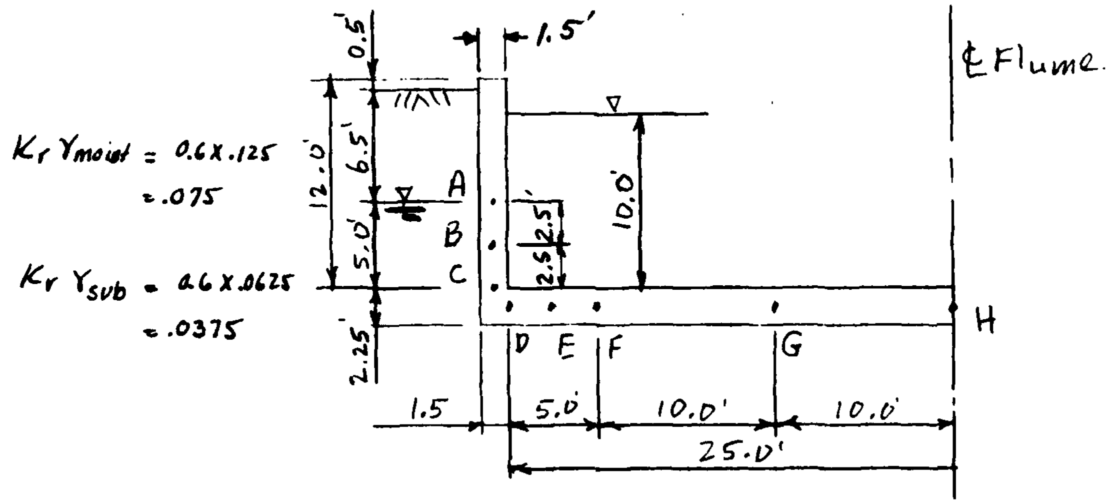
6819


SECTION OF FLUME - SECTION A
Scale 1/4" = 1'-0"
#5@12
#5@10
#8@12
#4 ⊔ Bars @12
#6@12
8'-6"
7'-6"
16'-6"
7'-0"
11'-6"
2'-0"
13'-6"
#4 @ 24
#6 @ 12
2'-3" Slab
Construction Joint (9" from ℄ Flume)
℄ Flume

D1-67

Flume Design

SECTION "B"



For Loading Condition, etc, see sheets 1 and 2

Point A $M = w l^3/6 = 0.075 \times 6.5^3/2 \times .38 = 3.91$ k-ft
$N = h\,t\,\gamma = 7.0 \times 1.5 \times 0.150 = 1.58$ Kips

Point B $M = 0.075 \times 6.5^2/2\,(4.97) + \frac{.0625 \times 2.5^3}{6} + \frac{.0375 \times 2.5^3 \times .38}{2}$
$+ .4875\,(2.5)^2\,.5$
$M = 7.87 + .163 + 0.11 + 1.52 = 9.67$ k-ft
$N = 9.5 \times 1.5 \times 0.150 = 2.14$ Kips

Point C $M = 0.075 \times 6.5^2/2 \times (2.47 + 5.0)$
$+ 0.0625 \times 5^3/6 + .0375 \times 5^3 \times .38/2 + \frac{.4875}{2} \times 5^2$
$M = 11.83 + 1.3 + .89 + 6.09 = 20.11$ k-ft
$N = 12.0 \times 1.50 \times 0.150 = 2.70$ Kips

Total WT $= 2.25 \times (25 + 1.5) \times 0.150 + 2.70 = 11.64375$
Total pressure $= \frac{11.64}{26.5'} = 0.439387$ K/ft
Uplift pressure $= (5.0 + 2.25) \times 0.0625 = 0.453125$ K/FT

Uplift F.S. = .97 ≈ 1.0 Use Consider it OK.

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel Flume FILE NO. 7622.00
SHEET NO. 11 OF 13 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 12/27/78 CHECKED BY WS DATE 1/23/79

Moments and Loads

Point D

item	Mom. at D	Vert ↓	Horiz →	arm	Mom ↷
Conc	$1.5 \times 14.25 \times 0.150$	+ 3.21		0.75	− 2.40
Soil →	$6.5^2/2 \times 0.075$		+ 1.58	8.595	+ 13.58
	$6.5 \times 7.25 \times 0.075$		+ 3.53	2.50	+ 8.84
	$7.25^2/2 \times 0.0625$		+ 1.64	1.2917	+ 2.12
	$7.25^2/2 \times 0.0375$		+ 0.98	1.63	+ 1.61
Found	0.453125×1.50	− 0.68		0.75	+ 0.51
		2.53	7.75		24.26

Point E $M = M_D + [w(\text{uplift}) - w(\text{concrete})]\, l^2/2 - V_D\, l$

$M = 24.26 + (0.453125 - 0.150 \times 2.25) \times 2.5^2/2 - 2.53 \times 2.5$
$M = 18.31$

Point F $M = 24.26 + 0.115625 \times 5.0^2/2 - 2.53 \times 5.0$
$M = 13.08$

6819

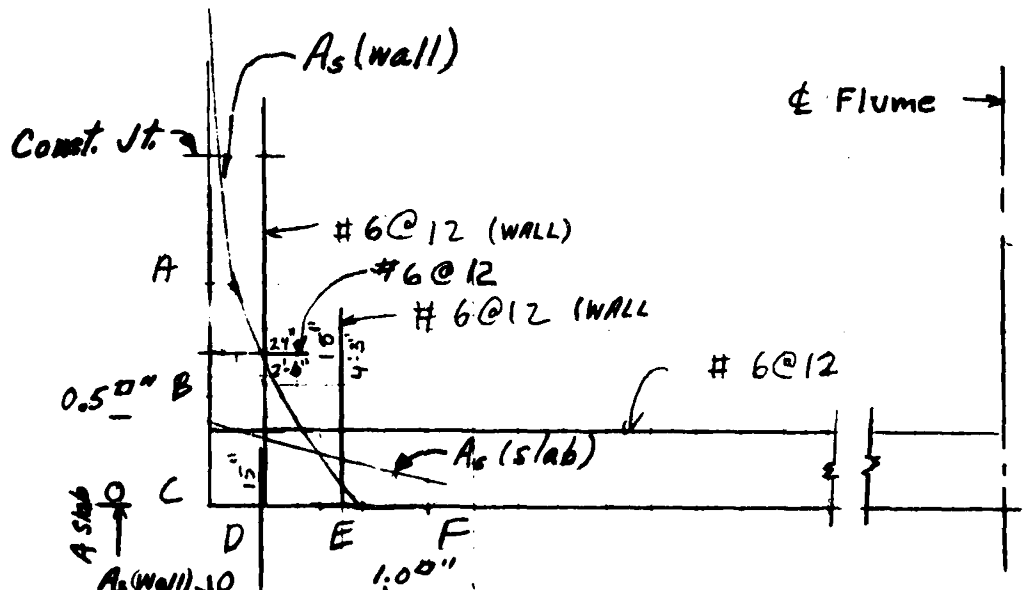
GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel Flume FILE NO. 7622.00
SHEET NO. 12 OF 13 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 12/27/78 CHECKED BY WS DATE 1/23/79

Concrete Design

$f_s = 20.0$ ksi $K = 152$
$f_c = 1.05$ ksi $a = 1.48$
$n = 9.2$ $j = 0.891$

Point	A	B	C	D	E	F
Moment k-ft	3.91	9.76	20.11	24.26	18.31	13.08
Normal kips	1.58	2.14	2.70	7.75	7.75	7.75
t inches	18.0	18.0	18.0	27.0	27.0	27.0
d inches	14.5	14.5	14.5	23.5	23.5	23.5
KF	31.96	31.96	31.96	84.18	84.18	84.18
e	25.20	60.56	94.88	47.56	38.35	30.25
NE	4.63	10.60	21.35	30.72	24.76	19.54
i	1.58	1.27	1.15	1.78	2.20	3.29
A_s	0.14	0.39	0.86	0.49	0.32	0.17

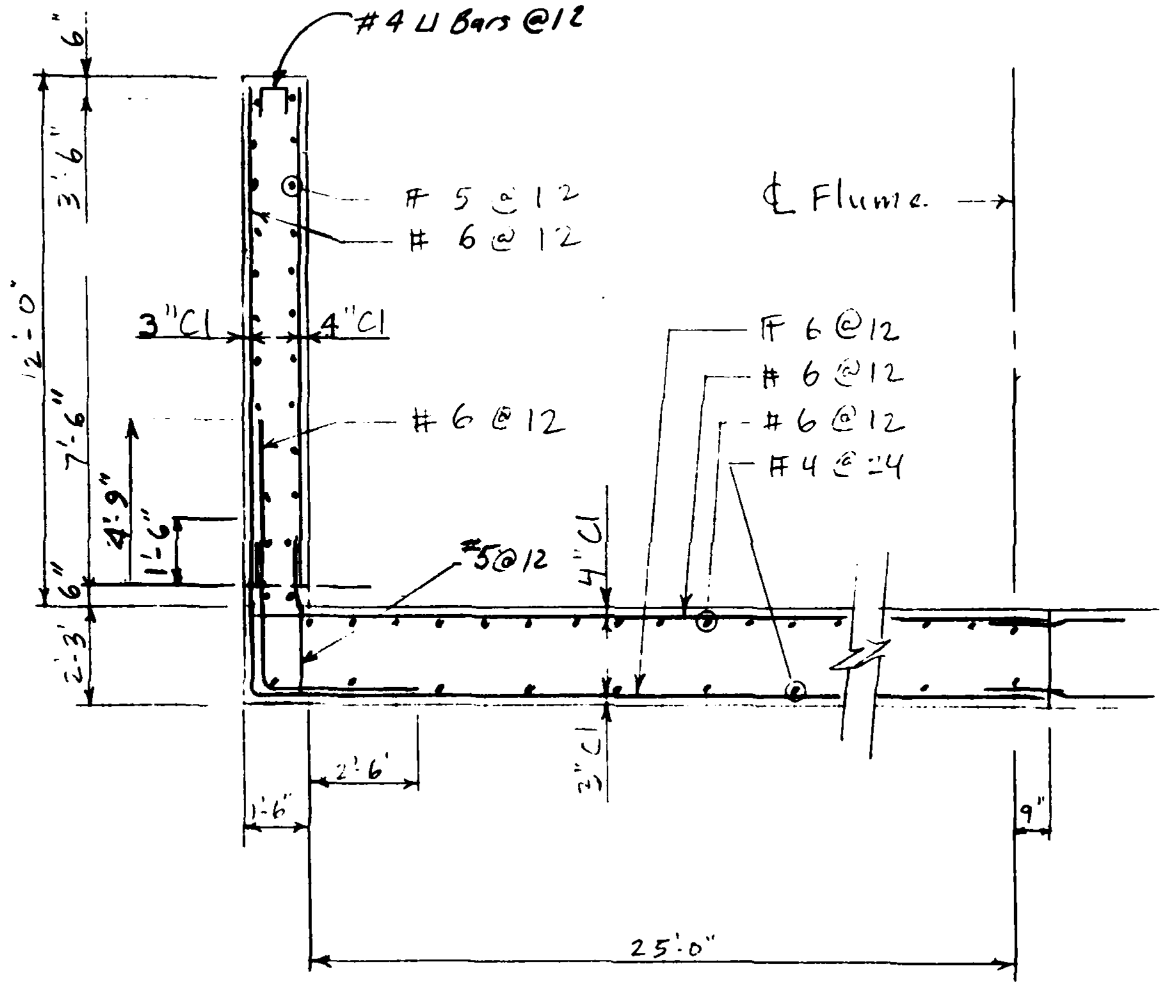


Scale Concrete 1/4" = 1'-0"
A_s 1.0" = 1.00□"

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel Flume FILE NO. 7622.00
SHEET NO. 13 OF 13 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY FvdG DATE 12/29/78 CHECKED BY WS DATE 1/29/79

Summary



SECTION OF FLUME
SECTION 8

Scale 1/4" = 1'-0"

8913

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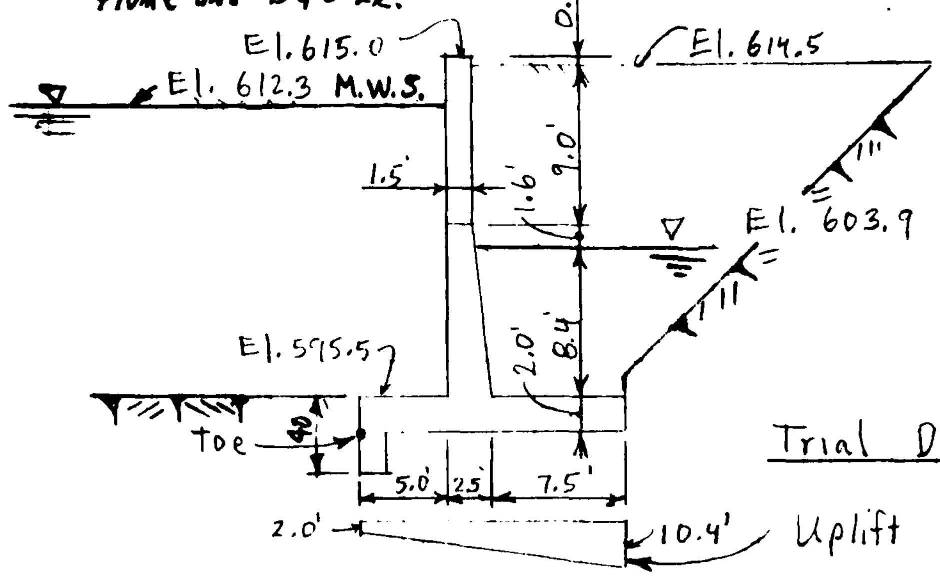
HARRISBURG, PA.

SUBJECT Diversion Channel Retaining Wall FILE NO. 7622.0
SHEET NO. 1 OF ___ SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 11/21/78 CHECKED BY WS DATE 1/23/79

Retaining Wall Design

Located Upstream the Diversion Channel Flume. Same wall section used for wingwall at right bank and wall between flume and B&O RR.



Trial Dimensions

Loading Condition - Sudden Drawdown

1. Channel Empty.
2. Soil submerged to an elevation midway between flood elevation and channel grade (50% drawdown)
3. K at rest = 0.60 for soil pressure for silt
4. Soil to within 6 inches
5. No surcharge loading.

Soil pressure

$\gamma_{soil} = 0.125\ k/ft^3$

$\gamma_{water} = 0.0625\ k/ft^3$

$K_r \gamma_{soil} = 0.075\ k/ft^3$

$K_r \gamma_{submerged\ soil}$ $.0375\ k/ft^3$

8815

Stability

In stability analysis, the key will be ignored and footing shall be assumed flat across bottom

Item	Description	Horiz.	Vert.	arm	M_O	M_R
SOIL	$\overline{10.6}^2 \times .5 \times 0.075$	4.21		14.428	60.74	
	$10.6 \times .075 \times 10.4$	8.27		5.2	42.99	
	$\overline{10.4}^2 \times .5 \times .0625$	3.38		3.467	11.72	
	$\overline{10.4}^2 \times .5 \times .0375$	2.03		3.952	8.01	
CONC	$1.5 \times 19.5 \times .15$		4.39	5.75		25.23
	$10 \times .5 \times .15$		.75	6.833		5.12
	$2 \times 15 \times .15$		4.50	7.50		33.75
SOIL	$1 \times 9 \times .125$		1.13	7.00		7.88
	$1 \times 10 \times .5 \times .125$		.63	7.1667		4.48
	$7.5 \times 19.0 \times .125$		17.81	11.250		200.39
U	$2 \times 15 \times .0625$		-1.88	7.50	14.06	
	$8.4 \times 15 \times .5 \times .0625$		-3.94	10.00	39.38	
		17.89	23.39		176.90	276.85

$$\frac{L}{4} = 3.75' \qquad e_r = \frac{276.85 - 176.90}{23.39} = 4.27' > 3.75'$$

$$\frac{L}{3} = 5.0'$$

Resultant within middle half

$$S_{s-f} = \frac{sA}{\Sigma H} = \frac{.200 \times 15 \times 144}{17.89} = 24.15 > 4 \therefore \text{O.K}$$

$$\frac{\Sigma H}{\Sigma V} = \frac{17.89}{23.39} = .765$$

$$p = \frac{\Sigma V\, 2}{e_r\, 3} = \frac{23.39 \times 2}{4.27 \times 3} = 3.65 < 10 \text{ KSF}$$

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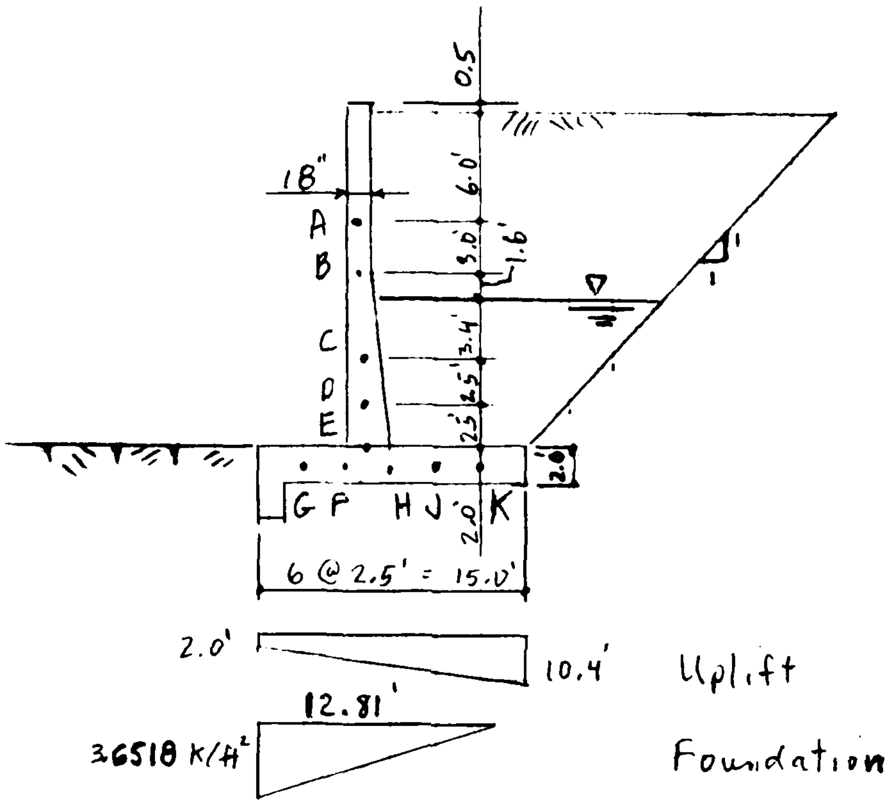
Design Moments



Point A

$M = w l^3/2 \times .38 \quad 0.075 \times 6.0^3/2 \times .38 = 3.08$ k-ft

$N = 1.5 \times 6.5 \times 0.150 = 1.46$ kips

Point B

$M = 0.075 \times 9.0^3/2 \times .38 = 10.38$ k-ft

$N = 1.5 \times 9.5 \times 0.150 = 2.14$ kips

Point C

$M = 0.075 \times 10.6^2/2 \times (10.6 \times .38 + 3.4) + 10.6 \times 3.4^2/2$
$\times 0.075 + 3.4^3/2 \times .38 \times .0$[illegible] $+ 3.4^3/6 \times .0$[illegible] $= 39.10$ k-ft

$N = 1.5 \times 14.5 \times 0.150 + 5 \times 0.5/2 \times (0.150 + 0.125)$
$+ 0.5 \times 9.0 \times 0.125 = 4.17$ kips

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HARRISBURG, PA.

SUBJECT Diversion Channel Retaining Wall FILE NO. 7622.00
SHEET NO. 4 OF ___ SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdC DATE 11/24/78 CHECKED BY WS DATE 1/23/79

Design Moments

Point D

$M = 0.075 \times 10.6^2/2 \times (10.6 \times 38 + 5.9) + 10.6 \times 5.9^2/2 \times 0.075 +$
$.0375 \times 5.9^3 \times \frac{38}{2} + 5.9^3/6 \times 0.0625 = 59.27$ k-ft

$N = 1.5 \times 17.0 \times 0.150 + 7.5 \times 0.75/2 (0.150 + 0.125)$
$+ 0.75 \times 9.0 \times 0.125 = 5.44$ kips

Point E

$M = 0.075 \times 10.6^2/2 \times (10.6 \times 38 + 8.4) + 10.6 \times 8.4^2/2 \times 0.075 +$
$.0375 \times 8.4^3 \times \frac{38}{2} + 8.4^3/6 \times 0.0625 = 90.81$ k-ft

$N = 1.5 \times 19.5 \times 0.150 + 10.0 \times 1.0/2 (0.150 + 0.125)$
$+ 1.0 \times 9.0 \times 0.125 = 6.87$ k-ft

Pressures

Toe $3.6518 + 2 \times 0.0625 - 2 \times 0.150 = 3.4768$ k/ft²

G $3.6518 \times \frac{10.31}{12.81} + \frac{0.0625}{15}(2 \times 12.5 + 10.4 \times 2.5) - 2 \times 0.150 = 2.8516$ k/ft²

F $3.6518 \times \frac{7.81}{12.81} + \frac{0.0625}{15}(2 \times 10.0 + 10.4 \times 5.0) - 2 \times 0.150 = 2.2264$ k/ft²

Heel $17.0 \times 0.125 + 2 \times 0.150 - 10.4 \times 0.0625 = 2.0250$ k/ft²

K $17.0 \times 0.125 + 2 \times 0.150 - (2.0 \times 2.5 + 10.4 \times 12.5) \times \frac{0.0625}{15}$

$- \frac{0.31}{12.81} \times 3.6518 = 2.0245$ k/ft²

J $2.675 - (2 \times 5.0 + 10.4 \times 10.0) \times \frac{0.0625}{15} - \frac{2.81}{12.71} \times 3.6518 = 1.398$

H $2.675 - (2 \times 7.5 + 10.4 \times 7.5) \times \frac{0.0625}{15} - \frac{5.31}{12.71} \times 3.5416 = 0.819$

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Design Moments

Point F $M = 3.6518 \times 5.0^2/3 + 2.2264 \times 5.0^2/6 = 39.71$ k-ft

$N_x = \left(\frac{f_x + f_{toe}}{2}\right) \times x \times \mu$

$N = \left(\frac{3.6518 \times 7.81}{12.81} + 3.6518\right) \times \frac{5.0}{2} \times 0.765 = 11.24$ kips

Point G $M = 3.6518 \times 2.5^2/3 + 2.8516 \times 2.5^2/6 = 10.58$ k-ft

$N = \left(\frac{3.6518 \times 10.31}{12.81} + 3.6518\right) \times \frac{2.5}{2} \times 0.765 = 6.30$ kips

Point H $M = 0.808 \times 7.5^2/6 + 2.0250 \times 7.5^2/3 = 45.65$ k-ft

$N = -\left(\frac{3.6518 \times 5.31^2}{12.81}/2\right) \times 0.765 = -3.07$ kips

Point J $M = 1.3926 \times 5.0^2/6 + 2.0250 \times 5.0^2/3 = 22.68$ k-ft

$N = -\left(\frac{3.6518 \times 3.21^2}{12.81}/2\right) \times 0.765 = -1.124$ kips

Point K $M = 2.1125 \times 2.5^2/6 + 2.0250 \times 2.5^2/3 = 6.328$ k-ft

$N = 0.$

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SUBJECT Diversion Channel Retaining Wall FILE NO. 7622.012
SHEET NO. 6 OF ___ SHEETS
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COMPUTED BY PvdG DATE 11/27/78 CHECKED BY WS DATE 1/23/79

Concrete Design

$f_s = 20.0$ ksi
$f_c = 1.05$ ksi
$n = 9.2$

$K = 152.$
$a = 1.45$
$j = 0.871$

Point	A	B	C	D	E
Mom k-ft	3.08	10.38	39.10	59.27	90.81
N Kips	1.46	2.14	4.17	5.44	6.89
t in.	18.0	18.0	24.0	27.0	30.0
d in.	14.5	14.5	20.5	23.5	26.5
KF	31.96	31.96	63.88	83.94	106.74
e	30.82	64.21	121.0	140.74	169.66
NE	3.75	11.36	42.05	63.80	97.41
i	1.72	1.27	1.19	1.17	1.16
As	0.10	0.42	1.15	1.56	2.14

Point	F	G	H	J	K
Mom. k-ft	39.71	10.58	45.65	22.68	6.33
N Kips	11.24	6.30	-3.07	-1.124	0
t in.	24.0	24.0	24.0	24.0	24.0
d in	20.5	20.5	19.5	19.5	19.5
KF	63.88	63.88	57.96	57.96	57.96
e	50.9	28.65	-170.51	-234.6	-
NE	47.67	15.04	43.62	21.97	6.41
i	1.56	2.75	0.91	0.93	1.00
As	1.01	0.18	1.67	0.82	0.22
As (N=0)	1.31	0.35			

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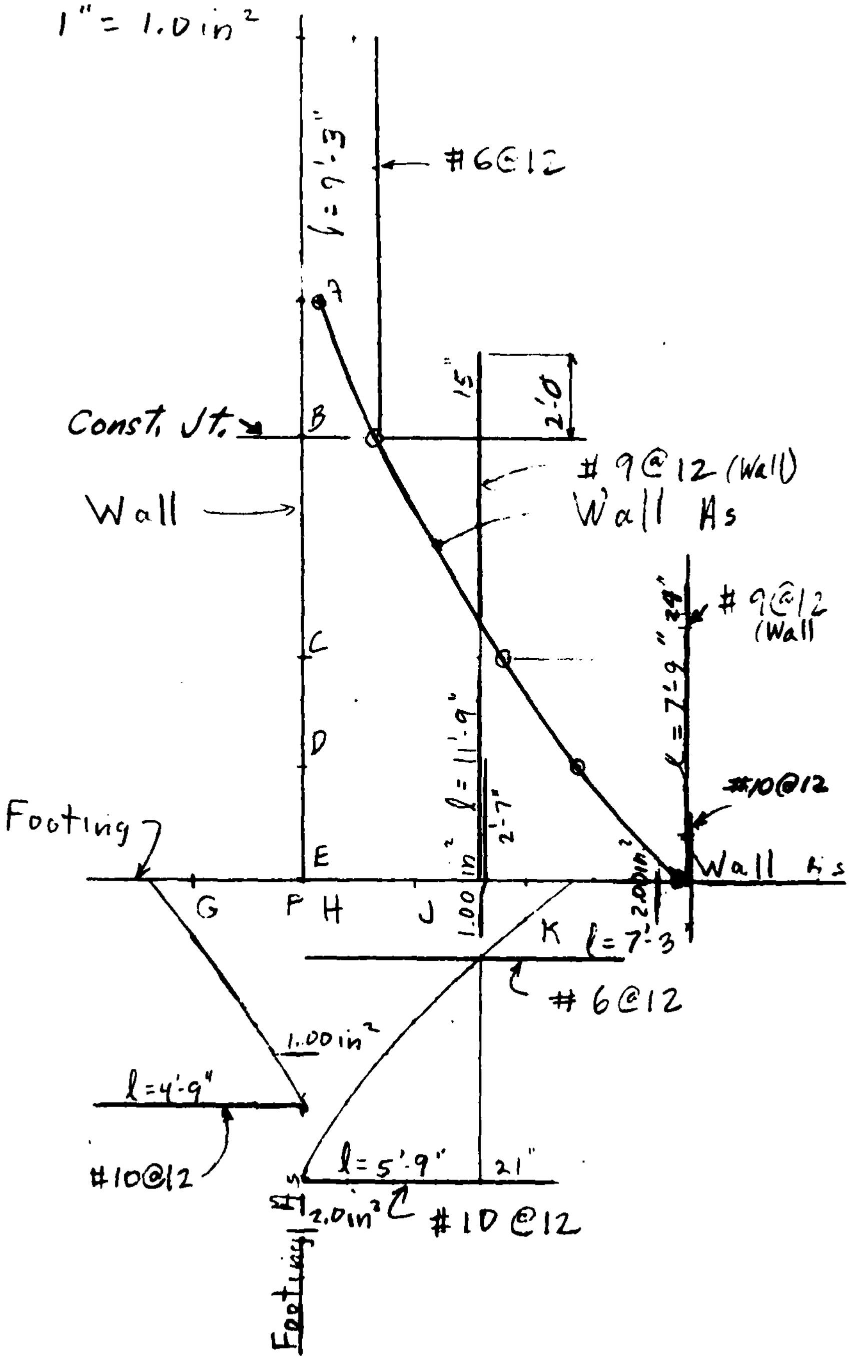
SUBJECT Diversion Channel Retaining Wall FILE NO. 7622.00
SHEET NO. 7 OF ____ SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 11/27/78 CHECKED BY WS DATE 1/23/79

Concrete Design

Scale: Concrete 1/4" = 1'-0"
As 1" = 1.0 in²



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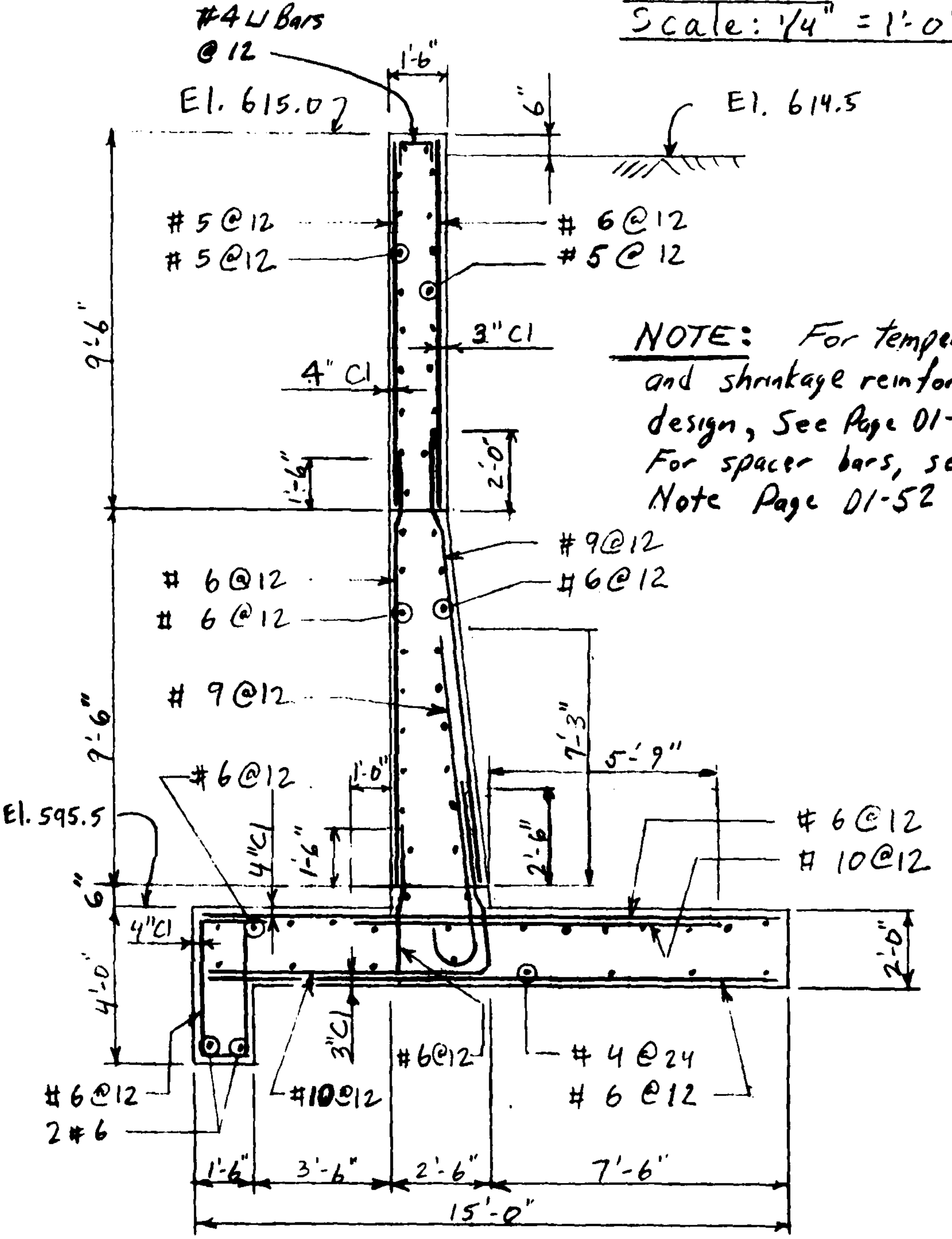
SUBJECT Diversion Channel Retaining Wall FILE NO. 7622.00
SHEET NO. 8 OF ___ SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 11/28/78 CHECKED BY WS DATE 1/23/79

SECTION C
Scale: 1/4" = 1'-0"



NOTE: For temperature and shrinkage reinforcement design, See Page 01-51. For spacer bars, see Note Page 01-52

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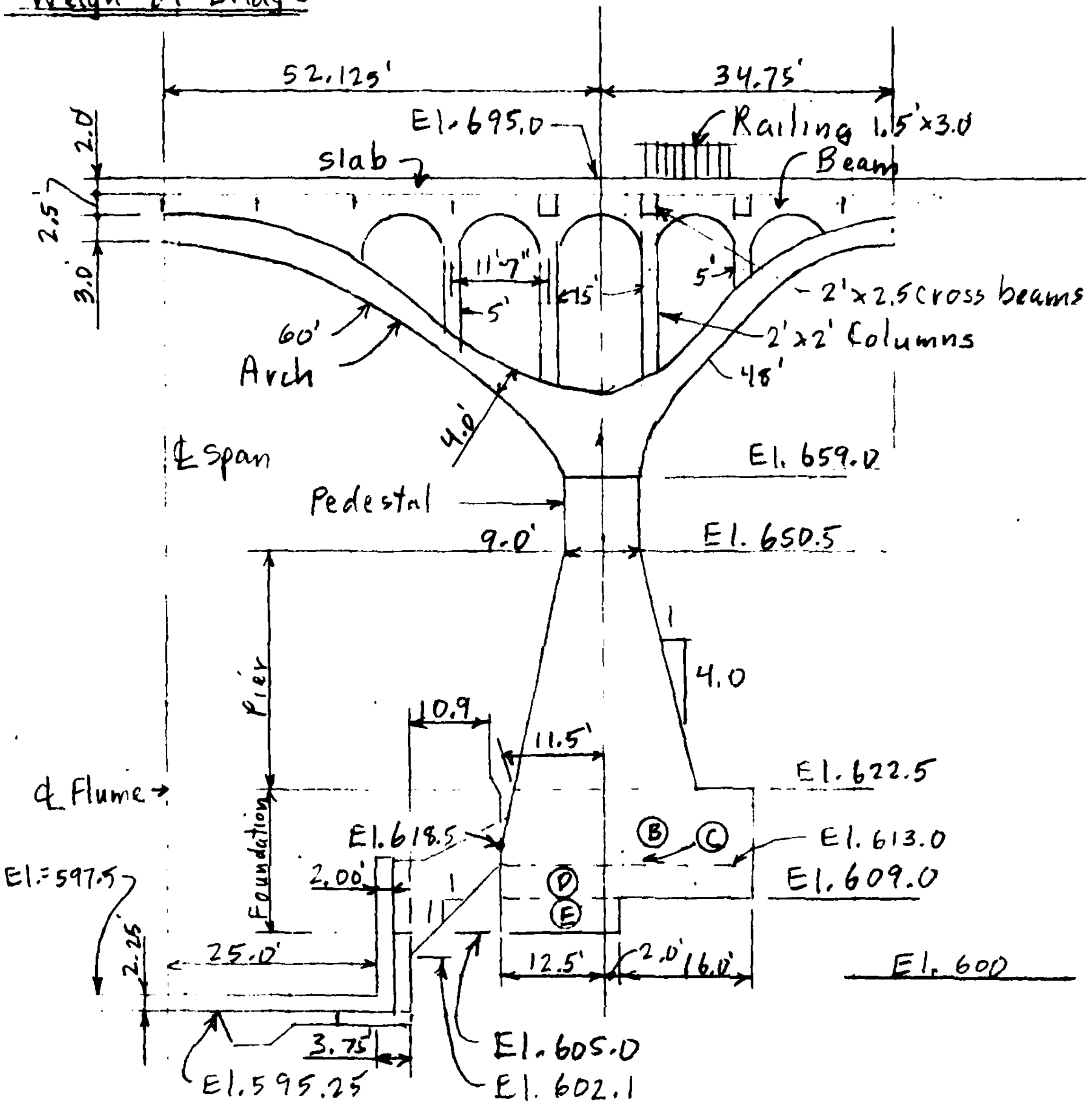
SUBJECT Diversion Channel — FILE NO. 7622.00
25 th Street Bridge — SHEET NO. 1 OF ___ SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY FvdG DATE 2/14/79 CHECKED BY WS DATE 3-2-79

Weight of Bridge



Section at ℄ Piers
Scale 1" = 20'

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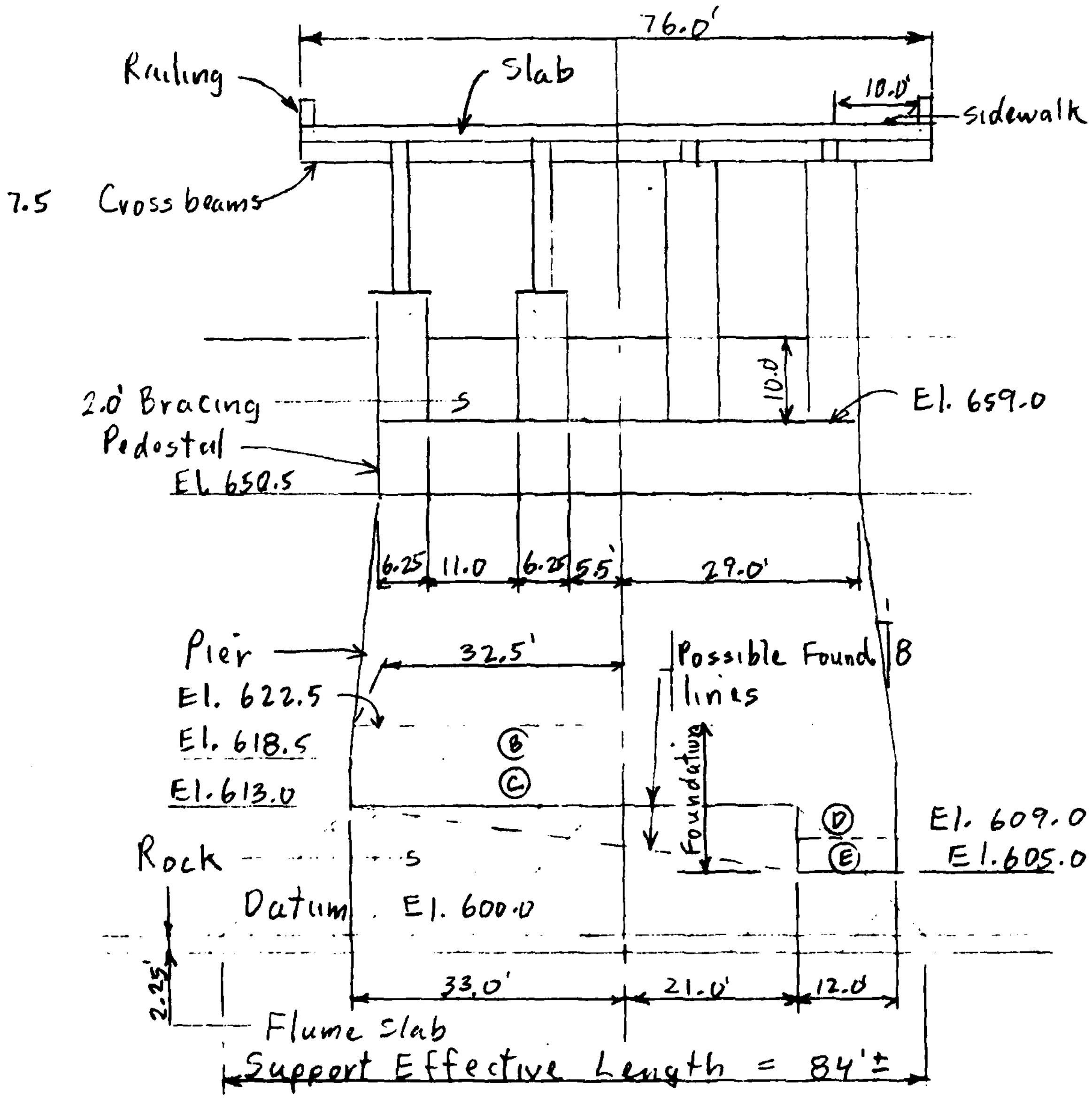
SUBJECT Diversion Channel Twenty fifth Street Bridge FILE NO. 7622.00
SHEET NO. 2 OF ____ SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 2/13/79 CHECKED BY WS DATE 3-2-79



Scale 1" = 20'

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SUBJECT Diversion Channel — Twenty Fifth Street Bridge
FILE NO. 7622.00
SHEET NO. 3 OF ___ SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 2/13/79 CHECKED BY WS DATE 3-2-79

Weight of Bridge - Dead Load

Slab $2.0 \times 76.0 \times (52.125 + 34.75) \times 0.150 = 1981$

Cross beam $7.5 \times 2 \times 2.5 \times (76 - 4 \times 2.0) \times 0.150 = 383$

Beam 4×4.0 (1) $\times 2.0 \times (52.125 + 34.75) \times 0.150 = 417$

Columns 8×5.0 (1) $\times 2.0 \times 2.0 \times 0.150 = 24$
8×15.0 (1) $\times 2.0 \times 2.0 \times 0.150 = 72$

Railing $2 \times 1.5 \times 3.0 \times (52.125 + 34.75) \times 0.150 = 117$

Arch $4 \times 48.0' \times 4.0 \times 6.25 \times 0.150 = 720$
$4 \times 60.0' \times 4.0 \times 6.25 \times 0.150 = 900$

Bracing $3 \times 10.0 \times 2.0 \times 11.0 \times 0.150 = 99$

Pedestal $8.5 \times 9.0 \times 58.0 \times 0.150 = 666$

Pier: A_1 = Area top $= 9 \times 58 = 522$
A_2 = Area bottom $= 23 \times 65 = 1495$
A_3 = Area mid section $= 16 \times 61.5 = 984$
WT. $= 1/6 \times 28\,(522 + 4 \times 984 + 1495) \times 0.150 = 4167.$

Found. B $[(65.0 \times 29.5) + (66 \times 30.5)]/2 \times 4.0 \times 0.15 = 1179$
C. $66.0 \times 30.5 \times 5.5 \times 0.15 = 1661$
D. $12.0 \times 30.5 \times 4.0 \times 0.15 = 220$ } (2)
E. $12.0 \times 14.5 \times 4.0 \times 0.15 = 104$ }

Total Dead Load 12709 kips

(1) Estimated average dimensions

(2) Exclude Found D. + E.: Dead Load = 12385 kips ← USE

D1-82

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Live Load *

Lane Loading $(0.640 \times 86.875 + 26.) \times 4 \times 0.75 = 245$

Side walk $10.0 \times 86.875 \times 2 \times 0.060 = 104$

Live Load 349 Kips

Rock between El 613.0 and El. 602.1

Base Area El. 613.0 $= 30.5 \times 66.0 = 2013\ ft^2$
Base Area El. 602.1 $= (30.5 + 2 \times 10.9) \times 66.0 = 3452\ ft^2$

WT Rock @ El. 602.1 $= 10.9 \times 3452 \times 0.165 = 6208$ Kips
wt Rock @ El 595.25 $= 6.85 \times 3452 \times 0.165 = 3901$ Kips

Total Loads & Pressures

Total Load = 1.10 Dead + Live (+ Rock)
Pressure $= \dfrac{\text{Total Load}}{\text{Area}}$

El. 613.0 Total Load = 13973 Kips
Pressure = 6.94 k/ft^2

El. 602.1 Total Load = 20181 Kips
Pressure = 5.846 k/ft^2

El. 595.25 Total Load = 24082 Kips
Pressure = 6.987 k/ft^2

* AASHTO, Standard Specifications for Highway Bridges, 1977. Art. 1.2. The W. 25th St. Bridge is assumed to have a roadway width of 48' and two sidewalks of 10' each. DI-83

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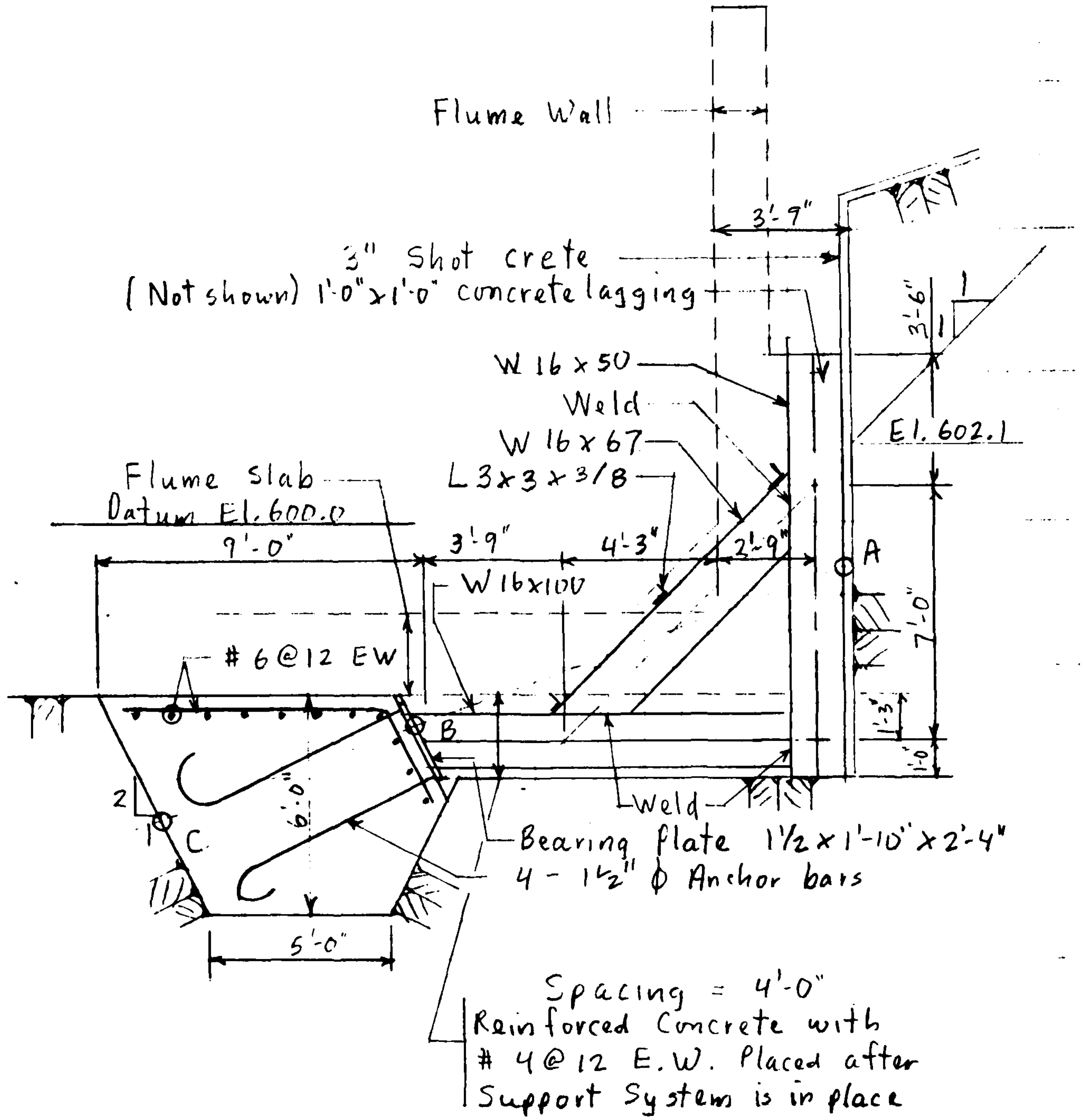
GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. 7622.00
Pier Protection SHEET NO. 5 OF ____ SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 2/26/79 CHECKED BY WS DATE 3-2-79

Design Cross Section and Summary



D1-84

Scale: 1/4" = 1'-0"

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HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. 7622.00
SHEET NO. 6 OF ___ SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdC DATE 2/21/79 CHECKED BY WS DATE 3-2-79

Design Loads and Assumptions

Assume uniform horizontal load equal to average of pressure at El. 602.1 and 595.25 times k equal to 0.6 (at rest).

$w = 0.6\,(5.846 + 6.987)/2 = \underline{3.85\ k/ft^2}$

Coefficient of Friction $= \underline{\mu = 0.45}$.

This coefficient of friction acts on the vertical wall of rock against the support.

Allowable Rock Bearing Press = $\underline{10.0\ k/ft^2}$

$F_y = 36.0$ ksi (A36 steel)

$f'c = 3000$ ksi

Use High Early Concrete for the foundation so that $f'c = 3000$ at 7 days.

$F_y = 36.0$ ksi

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SUBJECT Diversion Channel FILE NO. 7622.00
SHEET NO. 7 OF ___ SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 2/22/79 CHECKED BY WS DATE 3-2-79

Lagging

$w = 3.85$

Assume support spacing $= 4.0$ ft

$V = \frac{4 \times 3.85}{2} = 7.7$ kips , $b = 12$ inches

v max (concrete) $= 60$ psi

$d = \frac{1000\,V}{b \times v} = \frac{1000 \times 7.7}{12 \times 60} = 10.69$ in

$t = d + 1.5 =$ say 12 inches (set $d = 10.5"$)

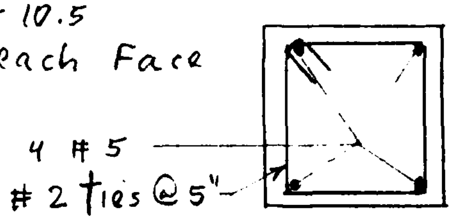
$M = \frac{w l^2}{8} = \frac{3.85 \times 4.0^2}{8} = 7.7$ k-ft

$F = \frac{b d^2}{12000} = \frac{12 \times 10.5^2}{12000} = 0.110$

$KF = 152.4 \times 0.110 = 16.8 > 7.7$ O.K.

$A_s = \frac{M}{a d} = \frac{7.7}{1.486 \times 10.5} = 0.493$

USE 2 #5 bars each Face



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SUBJECT Diversion Channel FILE NO.
Pier Protection SHEET NO. OF SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY pvd G DATE 7-13-79 CHECKED BY FF DATE 7-13-79

Discussion on Lagging

The lagging is an essential element of the support system. The lagging transfers the loading to the vertical structural member (W16x50).

The concrete lagging consists of individual elements of reinforced concrete block 12"x12"x3'-10". The blocks are laid horizontally, one on top of the other to form a wall. The ends of the blocks are wedged between the flanges of the vertical wide flange member of the steel support system. Shotcrete lining will be placed on the rock surface before the lagging is placed.

Details of the Support System are shown on Sheets DI-84 and DI-98

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GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. 7622.00
Pier Protection SHEET NO. 8 OF ___ SHEETS
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COMPUTED BY PvdG DATE 2/26/79 CHECKED BY WS DATE 3-2-79

Steel Design Procedure

Ref: Manual of Steel Construction, Seventh Edition, AISC.

Dimensions and Properties New W, HP and WT Shapes, Sept. 1978, AISC.

AISC, Part 5, Specifications and Codes

$F_y = 36.0$ ksi for A36 steel.

Section 1.5.1.2 $F_v = 0.40\ F_y = 14.5$ ksi

Sect. 1.5.1.3.1 Fa from Table 1-36
K = 1 Try Fa = 20.0 ksi., Kl/r < 29

Sect. 1.5.1.4. $F_b = 0.60\ F_y = 22.0$ ksi (non-compact)

Sect. 1.6.1 $\dfrac{f_a}{0.60 F_y} + \dfrac{f_b}{F_b} \leq 1.0$

Ref: Structural Steel Designer's Handbook, Merritt, 1972, Artical 5-32.

$F_p = 0.25\ f'_c = 0.750$ ksi

Sect. 1.17 Use E70xx Weld
$F_v = 21.0$ ksi.

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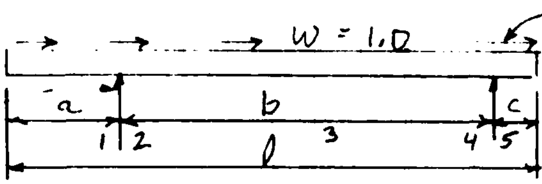
HARRISBURG, PA.

SUBJECT Diversion Channel — FILE NO. 7622.00
Pier Protection — SHEET NO. 9 OF ___ SHEETS
FOR Big Creek Flood Protection
COMPUTED BY PvdG DATE 2/26/79 CHECKED BY WS DATE 3-2-79

Vertical Member

Friction = 0.45 w

Support



$$R_{12} = \frac{wl(l-2c)}{2b}\ ; \quad V_1 = wa\ ; \quad V_2 = R_{12} - V_1$$

$$R_{45} = \frac{wl}{2b}(l-2a)\ ; \quad V_5 = wc\ ; \quad V_4 = R_{45} - V_5$$

$$M_1 = M_2 = wa^2/2 \qquad M_4 = M_5 = wc^2/2$$

$$M_3 = \frac{w}{8}\left(b^2 - 2a^2 - 2c^2\right)$$

V_1 a	b	V_5 c	l	R_{12}	V_2	R_{45}	V_4	M_1 M_2	M_4 M_5	M_3
3.0	7.5	1.0	11.5	7.28	4.28	4.22	3.22	-4.50	-0.50	4.53
3.25	7.25			7.53	4.28	3.97	2.97	-5.28		3.68
3.50	7.00			7.80	4.30	3.70	2.70	-6.13		2.81
3.75	6.75			8.09	4.34	3.41	2.41	-7.03		1.93
4.00	6.50			8.40	4.40	3.10	2.10	-8.00		1.03

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Vertical Member

Set $a = 3.5$, $b = 7.0$, $c = 1.0$, $\mu = 0.45$, spacing $= 4.0$ ft.

$R_{12} = 3.85 \times 7.80 \times 4.0 = 120.2$ Kips
@ a slope of 1 on 1 $R = 170.7$ Kips

$V_1 = 3.85 \times 3.50 \times 4.0 = 53.9$ kips
$V_2 = 3.85 \times 4.30 \times 4.0 = 66.3$ kips

$R_{4-5} = 3.85 \times 3.70 \times 4.0 = 56.9$ kips

$V_4 = 3.85 \times 2.70 \times 4.0 = 41.5$ kips
$V_5 = 3.85 \times 1.0 \times 4.0 = 15.4$ kips

$M_1 = 3.85 \times -6.13 \times 4.0 = 94.3$ kip-ft
$M_3 = 3.85 \times 2.81 \times 4.0 = 43.3$ kip-ft
$M_5 = 3.85 \times -0.50 \times 4.0 = 7.7$ kip-ft

Horizontal Shear $= 3.85 \times 0.45 \times 3.5 \times 4.0 = 24.3$ kips

Comp. above support $= 24.3$ Kips
Tension below support $= 95.9$ Kips

Design for: $M = 94.3$ K-ft
$V = 66.3$ kips
$N = 95.9$ Kips Tens

$$S = \frac{M}{F_b} = \frac{94.3 \times 12}{22.0} = 51.44 \text{ in}^3$$

$$A_w = \frac{V}{F_v} = \frac{66.3}{14.5} = 4.57 \text{ in}^2$$

$$A = \frac{N}{F_A} = \frac{95.9}{20.0} = 4.80 \text{ in}^2$$

6813

Vertical Member

$f_a = \frac{N}{A}$ $f_b = \frac{M \times 12}{S}$ $A_w \geq 4.57\ in^2$

$\frac{f_a}{0.60 F_y} + \frac{f_b}{F_b} \leq 1.0$

W Shape	A	d	t_w	(Shear) A_w	S_{xx}	$\frac{f_a}{.6F_y}$	$\frac{f_b}{F_b}$	sum
W 18x46	13.5	18.06	0.360	6.50	78.8	.329	.653	.982
W 16x50	14.7	16.26	.380	6.18	81.0	.302	.635	.937
W 16x45	13.3	16.13	.345	5.56	72.7	.334	.708	1.041
W 14x53	15.6	13.92	.370	5.15	77.8	.285	.661	.946

TRY W 16 X 50

8818

Diagonal Member

N = 170.7 kips: (Sh.10)
Pick a member with twice the necessary area to compensate for END Moments

$A = \left(\frac{170.7}{20}\right) \times 2 = 17.07$

r (radius of gyration)* is limited such that $Kl/r < 29$ and $Fs = 20.0$ ksi

$l = 8.0$ $K = 1.0$

$r = \frac{1.0 \times 8.0 \times 12}{29} = 3.3$ Not practical.

W Shape	A	r	$\frac{Kl}{r}$	Fa Table 1-36	fa	$\frac{fa}{Fa}$	
W 16x50	14.7	1.59	60.4	17.33	11.61	0.67	
W 14x53	15.6	1.92	50.0	18.35	10.94	0.60	
W 16x50	14.7	1.59	30.2	19.90	11.61	0.58	①
W 16x67	19.7	2.46	39.0	19.27	8.66	0.45	⟸
			19.5	20.60	8.66	0.42	①

① Assume bracing at mid point, $l = 4.0'$

TRY W 16x67

Bracing @ 2% N = 3.41 kips , $l = 6.0$ ft
USE L 3x3x3/8.

* See NOTE, Sheet DI-91a.

6813

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO.
Pier Protection SHEET NO. OF SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 7-13-79 CHECKED BY DATE

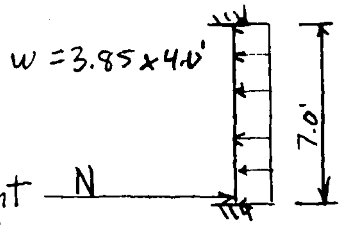
NOTE REGARDING RADIUS OF GYRATION

The design reference is Manual of Steel Construction, AISC, Seventh Edition, Part 5, Table 1-36. For a trial design, F_a is limited to 20.0 ksi and therefore $Kl/r \leq 29$. In the final analysis, $Kl/r = 39.0$ and $F_a = 19.27$ ksi.

6813

Horizontal Member

N = 56.9 Kips (sh.10.)



Assume Vertical Member to be fixed ended, with 1/2 moment going into this Horizontal Member

$$M = \frac{wl^2}{12} = \frac{3.85 \times 4.0 \times 7.0^2}{12} = 62.88 \text{ k-ft}$$

$$M = \tfrac{1}{2} M = \underline{31.44 \text{ k-ft}}$$

Calculate Moments, shears, Loads, 7.0' to the left of ℄ Vert. Mem, at intersection of Diagonal Member

Item	Computations	← Horiz	↓ Vert	arm	↶ Mom	↷ Mom.
Horiz	3.85 x 4.0 x 11.5	+177.1		4.75	+841.2	
Vert	3.85 x 4.0 x 11.5 x 0.45		+79.7	7.75		617.6

ΣM = 223.6 k-ft
$\bar{x}$ = -2.8056 ft
$\bar{y}$ = -1.2625 ft

6519

Horizontal Member

N = 177.1 Kips Assume fully braced.
M = 223.6 Kip-ft
V = 79.7 Kips

$f_a = \frac{N}{A}$ $A_w \geq \frac{V}{14.5} = \frac{79.7}{14.5} = 5.50 \text{ in}^2$

$f_b = \frac{12M}{S}$

$F_b = 22.0$ Ksi
$F_y = 36.0$ Ksi

$\frac{f_a}{0.6 F_y} + \frac{f_b}{F_b} \leq 1.0$

W Shape	A	d	t_w	(Shear) A_w	S_{xx}	$\frac{f_a}{.6 F_y}$	$\frac{f_b}{F_b}$	sum
W 18x86	25.3	19.39	0.480	8.83	166	.324	.735	1.059
W 18x77	28.5	18.59	0.535	9.95	188	.288	.649	.936
W 16x89	26.2	16.75	0.525	8.79	155	0.313	.787	1.100
W 16x100	29.4	16.77	0.585	9.93	175	0.279	.697	.976
W 14x99	29.1	14.16	0.485	6.87	157	0.282	.777	1.059

TRY W 16x100

8819

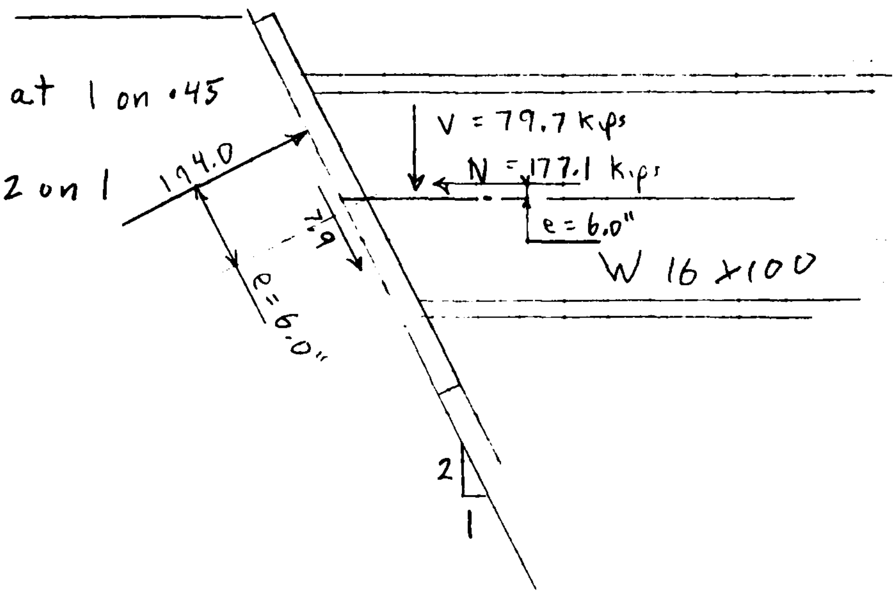
GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. 7622.00
Pier Protection SHEET NO. 15 OF ___ SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 2/27/79 CHECKED BY WS DATE 3-2-79

Bearing Plate

N = 177.1 kips
V = 79.7 kips
R = 194.2 kips at 1 on .45

R = 194.0 } at 2 on 1
V = 7.9 }



Assume eccentricity = 6"

$M = \frac{6}{12} \times 194.0 = 97$ k-ft

$F_p = 0.25 f'_c = 0.25 \times 3.00 = 0.750$

$A = \dfrac{194.0}{(0.750/2)} = 517.3 \text{ in}^2$

Try 28" x 20"

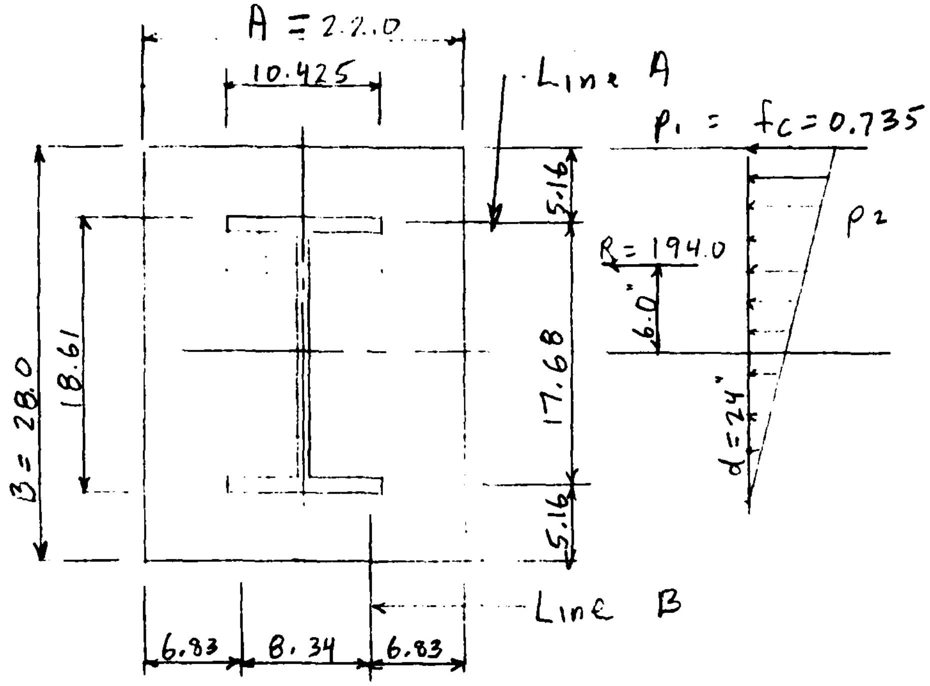
Fb (base plate) = 27.0 ksi

d = 16.97
d (slope) = 16.97 x 1.0966 = 18.61
bf = 10.425

R is resolved into components normal to the slope of 2 on 1 then: R = 194.0 kips
V = 7.9 kips

6812

Bearing Plate



$$d = \left(\frac{B}{2} - e\right)3 = \left(\frac{28}{2} - 6\right)3 = 24"$$

$$f_c = \frac{R\,2}{A\,d} = \frac{194.0 \times 2}{22 \times 24} = 0.735 \text{ ksi}$$

$$p_1 = 0.735$$

$$p_2 = \frac{0.735}{24}(24 - 5.16) = 0.577 \text{ ksi}$$

Moment about Line A

$$M = A\frac{l^2}{6}(w_1 + 2w_2)$$

$$M = \frac{22}{6}(5.16)^2(0.577 + 2 \times 0.735) = 199.8 \text{ k-in}$$

$$t = \sqrt{\frac{6M}{A\,F_b}} = \sqrt{\frac{6 \times 199.8}{22 \times 27.0}} = \sqrt{2.0182}$$

$t = 1.42$ say $1\frac{1}{2}$ in.

6919

Bearing Plate

Moment about Line B

$M = d \times fc/2 \times l^2/2$

$M = 24 \times 0.735/2 \times 6.93^2/2 = 205.7$ K-in

$t = \sqrt{\dfrac{6M}{B\ Fb}} = \sqrt{\dfrac{6 \times 205.7}{28 \times 27.0}} = \sqrt{1.6324} = 1.28$ in

Use 1½ inches

Use 4 - 1½" Φ Anchor bars

Foundation

K = 194.2 kips at a slope of 1 on 0.45 for 4.0 ft

R = 48.55 kips /ft $\qquad F_R = 10.0$ ksf

Graphically draw a Reaction line from mid point of Vertical Member on rock side (A), through bearing plate (B) such that e = 6.0 inches, to Foundation (C). *

Bottom of flume to C measured on a slope of 2 on 1 shall be at least:

$a > \dfrac{2R}{3 f_F} = \dfrac{2 \times 48.55}{3 \times 10.0} = 3.24'$

Total depth of trench (l) shall be less than 3a = 9.7'

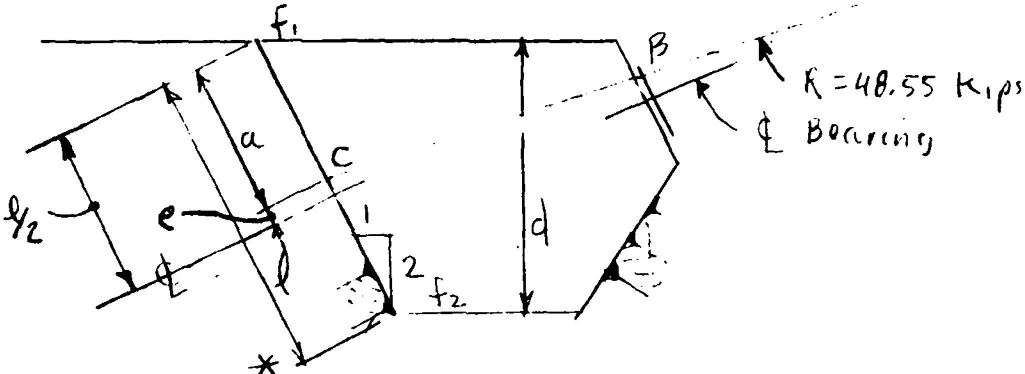
D1-96

* See Sheet 5, 18

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel Pier Protection FILE NO. 7622.00
SHEET NO. 18 OF ___ SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 2/27/79 CHECKED BY WS DATE 3/5/79

Foundation



FORMULAS*

$f_1 = 10.0 \ K/ft^2$ max. found. pressure.

$f_1 = \frac{R}{l^2}(l + 6e) \leq 10$ & $f_2 = \frac{R}{l^2}(l - 6e) \geq 0.0$

$a + e = l/2$ or $e = l/2 - a$

Substituting $(l/2 - a)$ for e gives the following:

$f_1 = \frac{R}{l^2}(4l - 6a) \leq 10$ $\qquad f_2 = \frac{R}{l^2}(6a - 2l) > 0$

ℓ	a	f_1	f_2	d	
8.94	3.75	8.06	2.80	8.0	
8.94	3.08	10.50	0.36	8.0	
10.06	3.08	10.44	-0.79	9.0	
7.53	3.75	6.98	5.43	7.0	
6.71	3.75	4.67	9.80	6.0	USE

* For Note regarding Formulas, See Sheet D1-97a

6819

NOTE REGARDING FORMULAS ON SHEET DI-97

The first two equations, $f_1 = R(l+6e)/l^2 \leq 10$ and $f_2 = R(l-6e)/l^2 \geq 0$ are basic foundation pressure equations.

f_1 and f_2 are the foundation pressures at each end of the foundation;
R is the applied load, normal to the foundation;
l is the length of the foundation; and
e is the eccentricity of the applied load.
$a + e = l/2$ or $e = l/2 - a$

The second two equations are the same except $(l/2 - a)$ has been substituted for e.

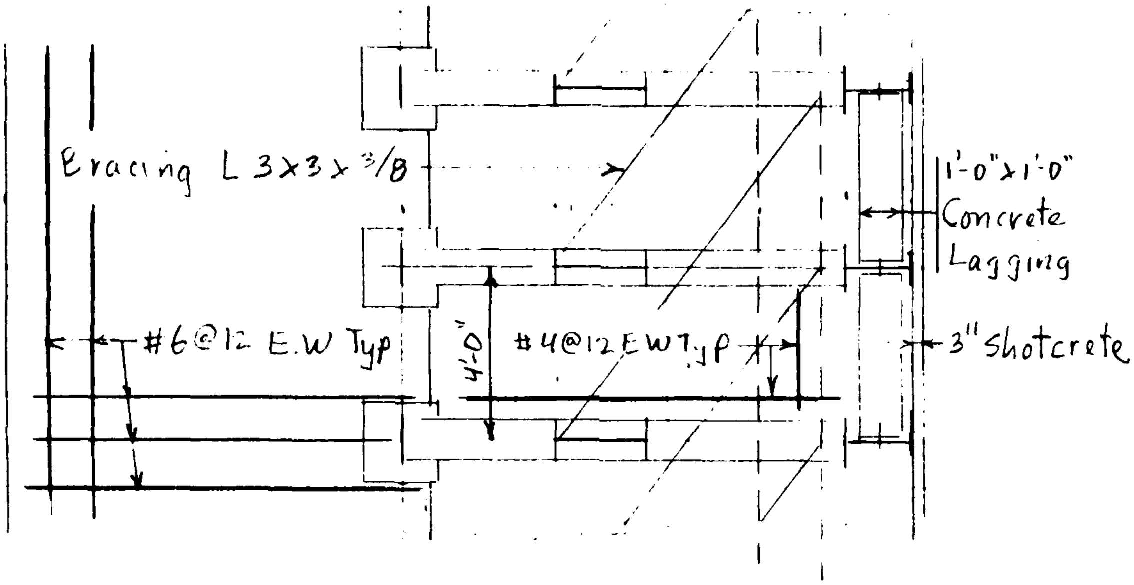
The foundation in this case is assumed to consist of only the sloping portion of the trench.

6813

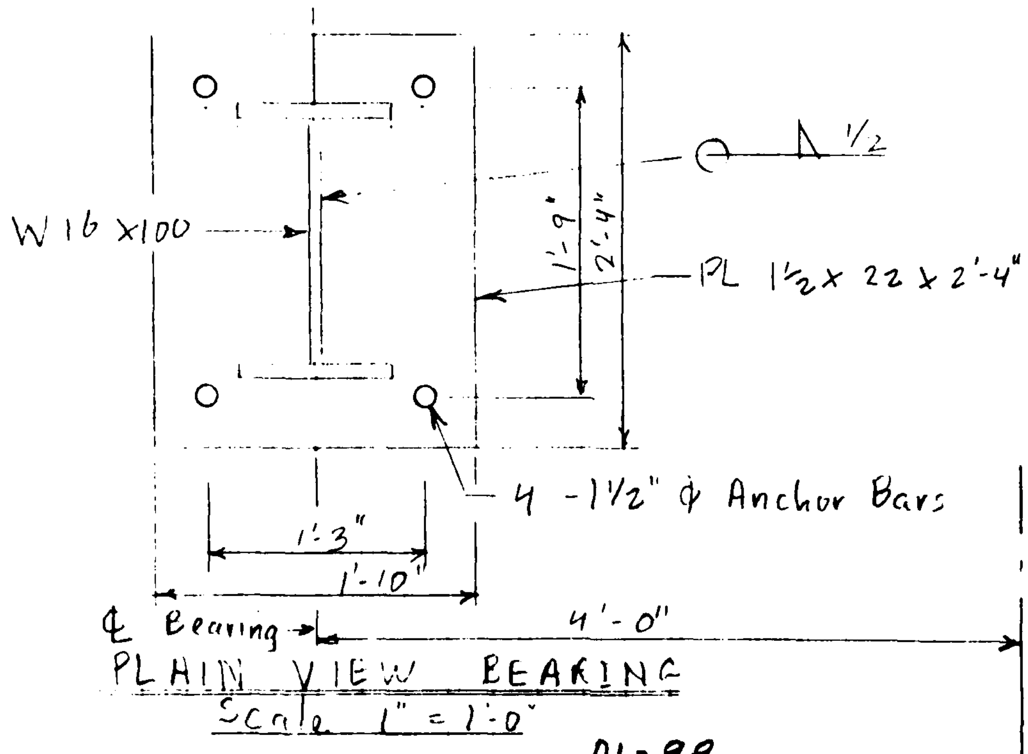
GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel / Pier Protection FILE NO. 7622.00
SHEET NO. 19 OF ___ SHEETS
FOR Tug Creek Flood Control Project
COMPUTED BY PvdG DATE 2-27-79 CHECKED BY WS DATE 3-5-79

Summary



PLAN VIEW. SUPPORT SYSTEM
Scale 1/4" = 1'-0"



PLAIN VIEW BEARING
Scale 1" = 1'-0"

D1-98

6819

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

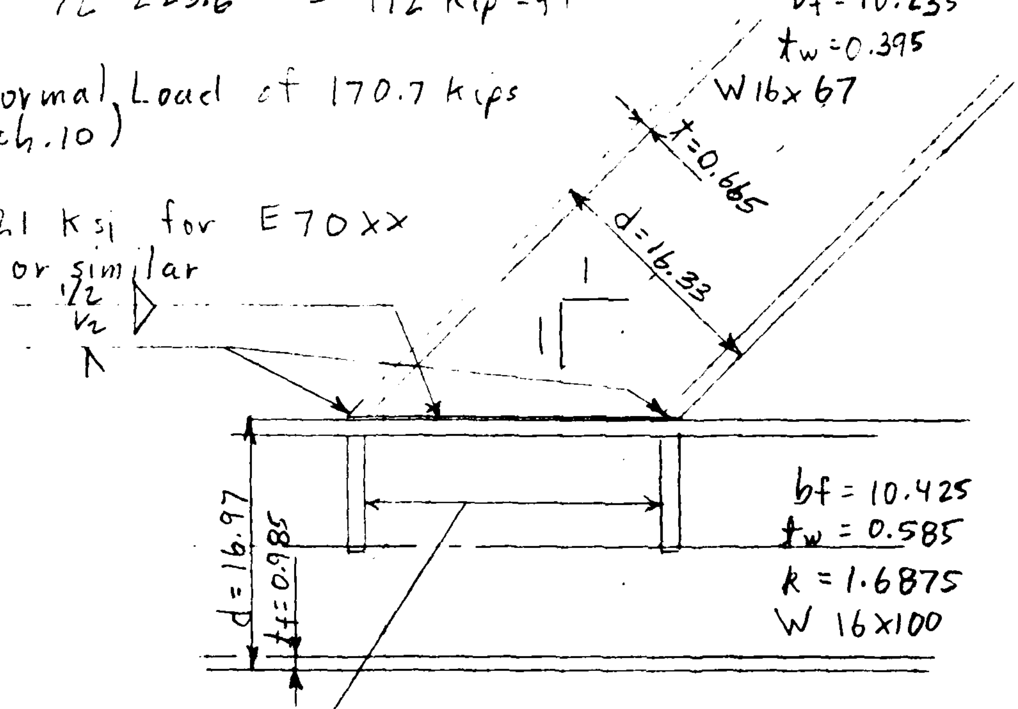
SUBJECT Diversion Channel Pier Protection FILE NO. 7622.00
SHEET NO. 20 OF ___ SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 3/1/79 CHECKED BY WS DATE 3-5-79

Weld Design

Use 1/2 of Moment from sheet 13
= 1/2 223.6 = 112 kip-ft

Use Normal Load of 170.7 kips (sh.10)

fv = 21 ksi for E70xx or similar



1 Plates Each side, each point 3/8 x 5" x 7 1/2"

Ref: AISC, p. 4-88

$T = \frac{12M}{d} = \frac{12 \times 112}{16.33} = 82.3$ Kips per Flange

$N = \frac{170.7}{2} = 85.4$ Kips per Flange

Total = 167.7 Kips

Shear = $167.7 \times \sqrt{.5}$ = 118.5 Kips
Reaction = 120k say 120 Kips

P1-99

8819

Weld Design

Shear 120 kips

USE Complete penetration TC-L4b Weld
Single Bevel Groove

$t = 0.665 \quad F_v = 21.0, \quad b = 10.235$

$$f_v = \frac{120}{0.665 \times 10.235} = 17.63 < 21.0 \quad O.K$$

Stiffener Design

$A_{st} = A_p - t(t_B + 5K)$

$R = 120$
$A_p = 0.665 \times 10.235 \qquad b = 10.235$
$t = 0.585$
$t_B = 0.665$
$K = 1.6875$

$A_{st} = 0.665 \times 10.235 - 0.585(0.665 + 5 \times 1.6875)$

$A_{st} = 1.481 \text{ in}^2 \qquad b/t \; max = 15.8$

set $b = 5.0$
$t = \frac{5.0}{15.8} = 0.316$ say 3/8"

$$\text{Min weld size} = \frac{t_w \times F_{vp}}{2\sqrt{0.5}\,F_{vw}} = \frac{0.585 \times 14.5}{2 \times \sqrt{0.5} \times 21.0} = 0.286$$

size = 5/16" weld.

$$\text{Length of weld} = \frac{A_{st} \times F_y}{0.928\,D \times 1.65} = \frac{5 \times 3/8 \times 36}{0.928 \times 5 \times 1.65} = 8.82''$$

Weld around, Length $= 2(4+6.5) = 21''$ O.K

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

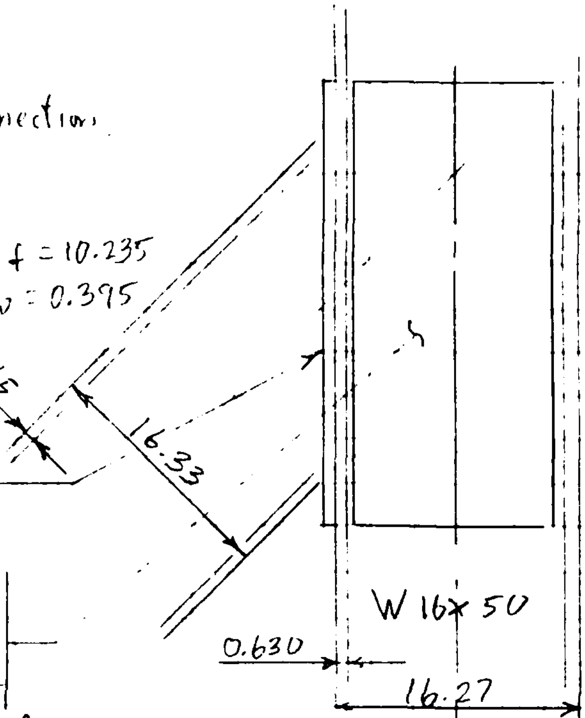
SUBJECT River Channel — 25th Street Bridge Pier Protection — FILE NO. 1622.00 — SHEET NO. 22 OF ___ SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY Pvd G DATE 3/3/79 CHECKED BY WS DATE 3-5-79

Weld Design

Vertical and Diagonal Connection

Ref: AISC, page 4-88

Item 5



A: Add Flange Cover Plate
$1/4 \times 7 \times 2'\text{-}6''$

B: Add 2 Web Cover Plates
$1/4 \times 14 \times 2'\text{-}6''$
grind to fit beam fillet

tw = web thickness or t. Reference is Manual of Steel Construction, AISC, 7th Ed., Pg. 4-88 and Part 5, Sec. 1.15; t and tw both refer to web thickness.

$t_w = 0.380$
$b_f = 7.070$
$k = 1.3125$
$d_c = 13.635$

$$t_w < \frac{A_p}{t_b + 5k} = \frac{0.665 \times 10.235 \times \sqrt{0.5}}{0.665 + 5 \times 1.3125}$$

$t_w = 0.380 < 0.666$ ∴ Need Stiffeners

$$t_w < \frac{d_c}{5\sqrt{F_y}} = \frac{13.635}{5 \times \sqrt{36}} = 0.4545$$ ∴ Need Stiffeners

$$t_f < 0.4\sqrt{A_p} = 0.4 \times \sqrt{10.235 \times 0.665 \times \sqrt{0.5}} = 0.738$$

Add Flange cover plate thickness equal to
$0.738 - 0.630 = 0.108 = 1/8''$

Add 2 Web cover plates $\frac{0.666 - 0.380}{2} = 0.143 = 3/16$

USE 1/4" plates for Flange and web.

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. 7822.0c
Fire Protection SHEET NO. 23 OF ___ SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdC DATE 3/2/79 CHECKED BY WS DATE 3-5-79

Connections - Vertical & Horizontal

Horizontal Member W 16 × 100 $t_f = 0.985$
$b_f = 10.425$

Vertical Member W 16 × 50 $t_f = 0.630$
$b_f = 7.070$
$k = 1.3125$
$d_c = 13.635$

$t_w < \frac{0.985 \times 10.425}{0.985 + 5 \times 1.3125} = 1.361$ Need stiffeners

$t_w < \frac{13.635}{\sqrt{36}} = 0.4545$ Need stiffeners

$t_f < 0.4\sqrt{10.235 \times 0.665} = 1.044''$

Add Flange Cover Plate of 0.414" or 1/2"

k new becomes 1.3125 + 0.5 = 1.8125

$t_w < \frac{0.985 \times 10.425}{0.985 + 5 \times 1.8125} = 1.022''$

Add 2 Web Plates of $\frac{1.022 - 0.380}{2} = 0.321$
$= 3/8''$

USE 1 Flange Cover Plate, PL 1/2 × 7 × 2'-0"

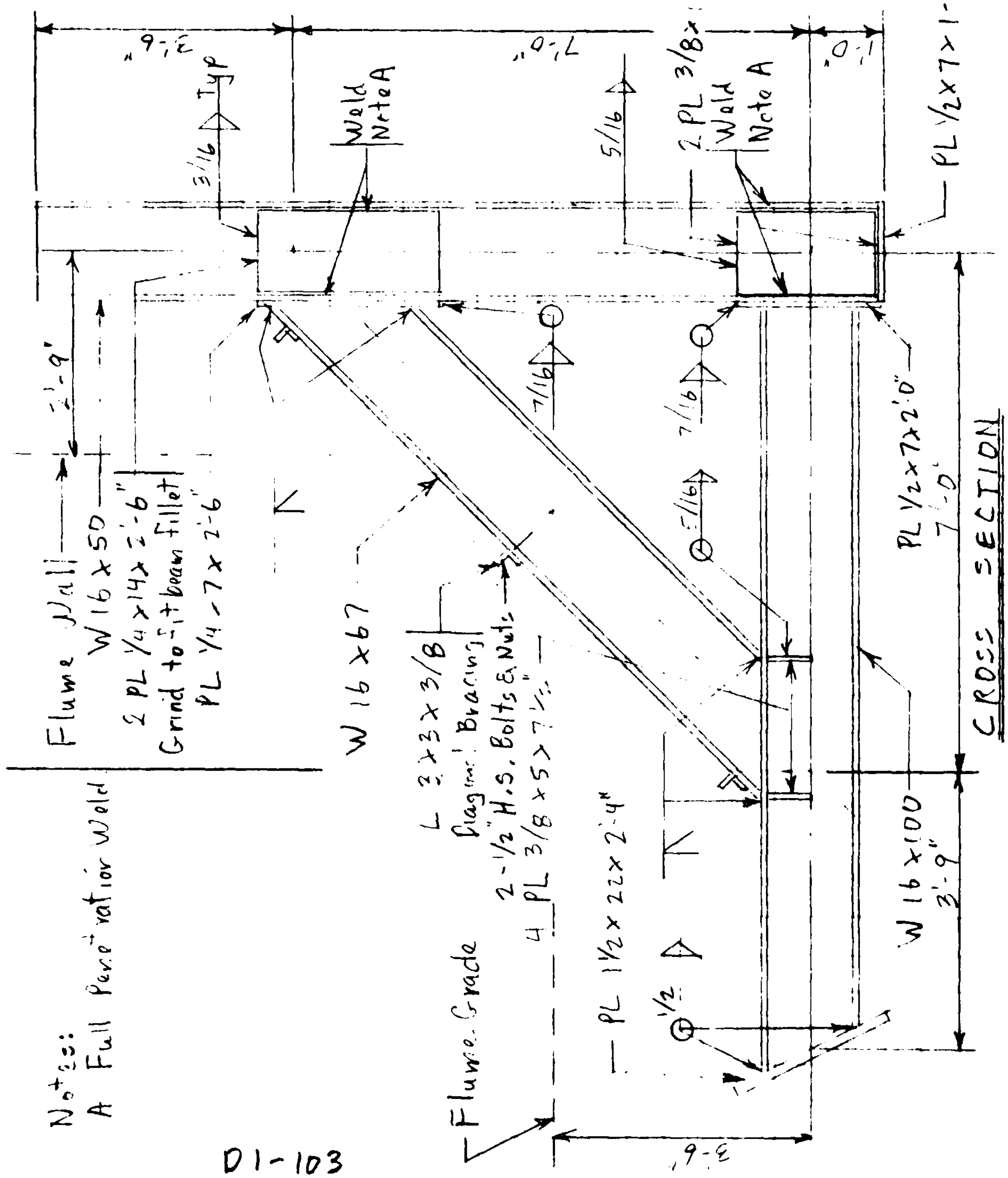
USE 2 Web Cover Plates, PL 3/8 × 14 × 2'-0"
(grind to fit beam fillet

6819

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel — Pier Protection — FILE NO. 7622.00
SHEET NO. 24 OF ____ SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY ____ DATE ____ CHECKED BY WS DATE 3-5-79

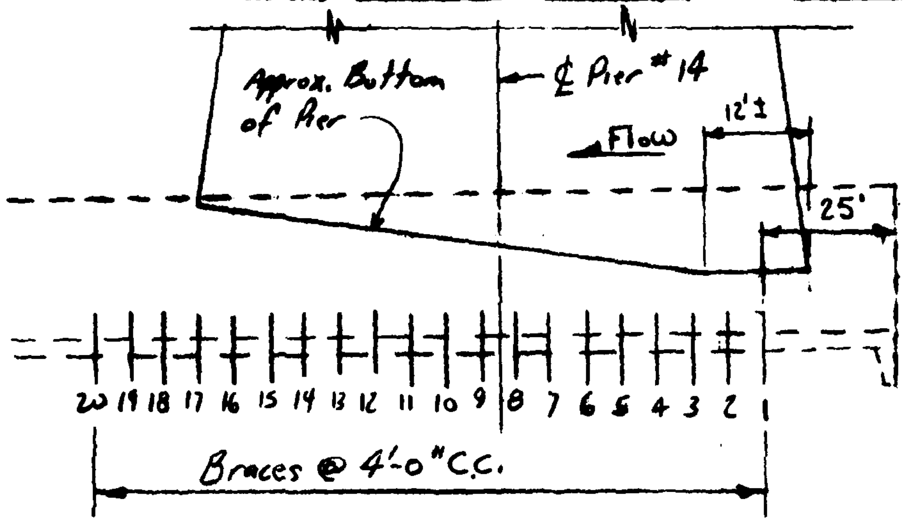
Summary
See also Sheets 5, 19



D1-103

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT: Diversion Channel
Pier Protection
FOR: Big Creek Flood Control Project
COMPUTED BY: FF DATE: 3-5-79 CHECKED BY: ______ DATE: ______
FILE NO. ______
SHEET NO. ____ OF ____ SHEETS



GENERAL CONSTRUCTION PROCEDURE

1. Excavate overburden along reach of bracing system.
2. Place shotcrete on rock surface along pier (area between vertical rock cut and pier).
3. Start rock excavation at upstream end of pier and work in a downstream direction.
4. Excavate as required for brace ① and ②. Shotcrete vertical face after each 5-foot lift of rock excavation.
5. Place concrete anchor blocks. Let set for 7 days before proceeding with step 6.
6. Install braces ① and ②.
7. Install lagging (Place mortar between lagging and shotcrete, wedge lagging at braces).
8. Excavate rock for braces ③ & ④ + continue sequence. Concrete between concrete anchor block and lagging placed at Contractor's option.

6619

Comment on Design

Assumptions and procedures are believed to be on the conservative side. It was felt that this was necessary because of the importance of the bridge. Also, the bridge is old and not in good condition. The fillet at the bottom of the wall is not believed to have any significant affect on the hydraulics. Pier #14 takes the load from unequal spans. The actual loading on the pier is angled into the abutment. For design purposes, it was assumed that the load was vertical.

BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

PHASE II
GENERAL DESIGN MEMORANDUM

APPENDIX D

DESIGN ANALYSIS

AUGUST 1979

SUBAPPENDIX D2

COMPUTATIONS FOR DESIGN
OF
RAILROAD BRIDGES AND TEMPORARY TRESTLE

SUBAPPENDIX D2

COMPUTATIONS FOR DESIGN OF RAILROAD BRIDGES AND TEMPORARY TRESTLE

CONTENTS

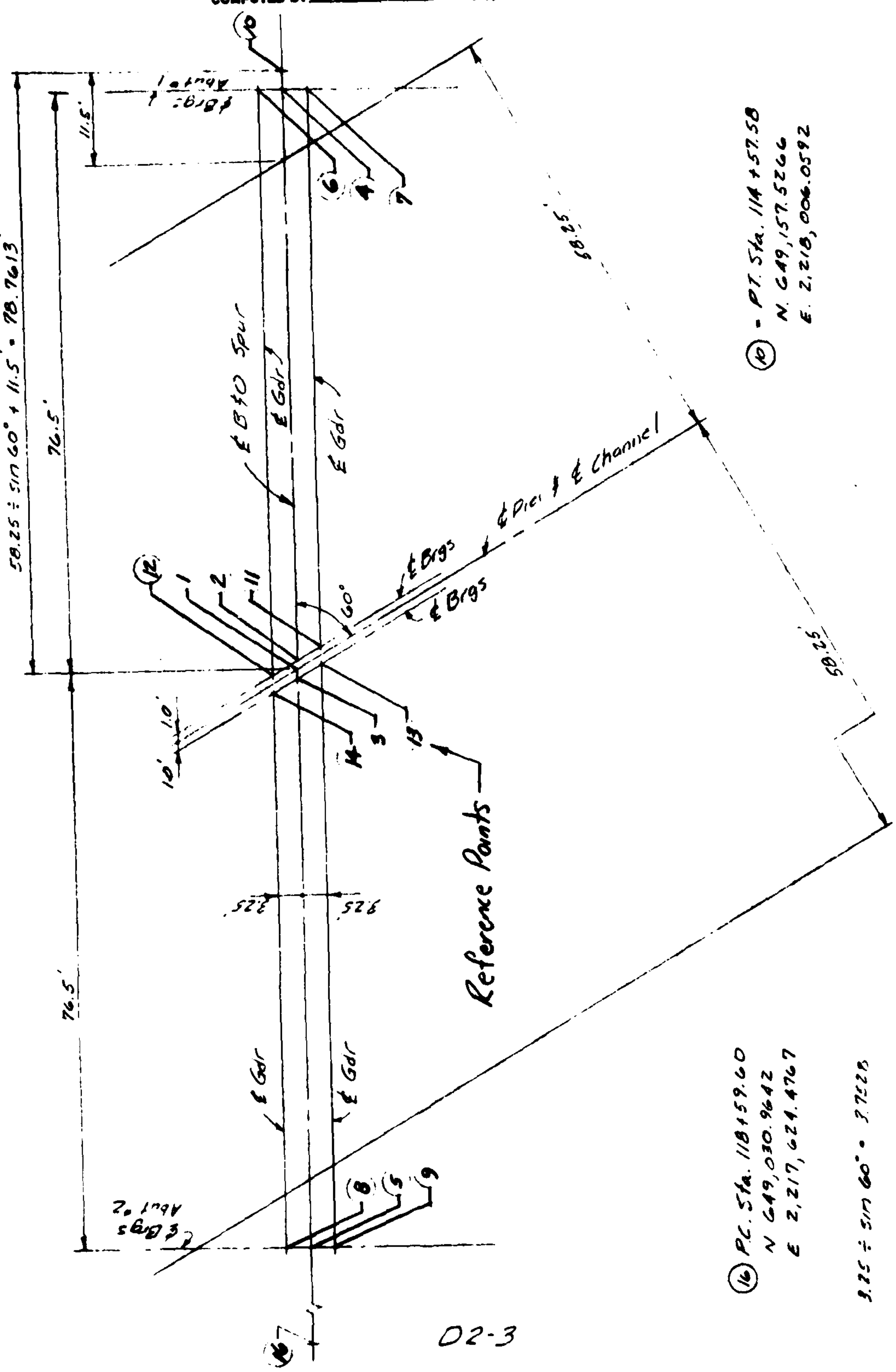
NOTE:

The Beam Deflection Program, the Retaining Wall-Abutment Program, and the Program for Load and Moment Points for Interactive Curve have been verified by hand computations.

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Cleveland Flood Control Project FILE NO.
Spur Line Bridge SHEET NO. OF SHEETS
FOR
COMPUTED BY KSM DATE 2-1-79 CHECKED BY DLH DATE 2-3-79

GEOMETRY - Spur Line Bridge



D2-3

8819

Geometry - Spur Line Bridge

by: RSM (2-1-79)
chkd: D.J.T. (2-8-79)

```
      edit cl(cog) ipli
EDIT  run

COMMAND:
?     clr
?     1 99 1
?     0 0 0

COMMAND:
?     str
?     10 649157.5266 2218006.0592   PT Sta. 114+57.58
?     16 649030.9642 2217624.4767   PC Sta. 118+59.60
?     0 0 0

COMMAND:
?     llm
?     10 16 1 78.7613
  1  649132.7315 2217931.3026  ℄ Pier
?     10 16 2 77.7613
  2  649133.0463 2217932.2518
?     10 16 3 79.7613
  3  649132.4167 2217930.3535
?     1 10 4 76.5
  4  649156.8147 2218003.9129  ℄ Brgs. Abut #1
?     1 16 5 76.5
  5  649108.6483 2217858.6924  ℄ Brgs. Abut #2
?     0 0 0 0
```

Reference Points, See Sheet D2-3.

```
COMMAND:
```
~~? 4 5 3.25 6 0~~
~~COMMAND NOT FOUND~~

~~COMMAND:~~

```
C_
```

NOTE:
Sheets D2-4 thru D2-6, D2-8 thru D2-14, and D2-16 thru D2-19 are the output from a COGO Program. For writeup of program, see Subappendix D5.

Geometry - Spur Line Bridge

by: RSM (2-1-79)
Chkd: DLH (2-8-79)

```
        pln
?       4 5 3.25 6 8
  6   649159.8995 2218002.8897
  8   649111.7331 2217857.6692
?       5 4 3.25 9 7
  9   649105.5636 2217859.7155
  7   649153.7300 2218004.9360
?       0 0 0 0 0

COMMAND:
?       lan
?       16 3 14 3.7528  60 00 00
 14   649134.9108 2217927.5493
?       10 3 13 3.7528  60 00 00
 13   649129.9226 2217933.1576
?       16 2 12 3.7528  60 00 00
 12   649135.5404 2217929.4476
?       10 2 11 3.7528  60 00 00
 11   649130.5523 2217935.0559
?       0 0 0 0 0 0 0

COMMAND:
?       ibr
?       10 16
    SW  71- 39-  1.69   DIST=      402.0239
?       10 4
    SW  71- 39-  1.69   DIST=        2.2613
?       10 2
    SW  71- 39-  1.69   DIST=       77.7613
?       10 1
    SW  71- 39-  1.69   DIST=       78.7613
?       10 3
    SW  71- 39-  1.69   DIST=       79.7613
?
```

```
       10 5
   SW  71- 39-  1.69   DIST=    155.2613
?      6 12
   SW  71- 39-  1.74   DIST=     77.3764
?      7 11
   SW  71- 39-  1.63   DIST=     73.6236
?      14 8
   SW  71- 39-  1.63   DIST=     73.6236
?      13 9
   SW  71- 39-  1.74   DIST=     77.3764
?      12 14
   SW  71- 39-  1.69   DIST=      2.0000
?      2 3
   SW  71- 39-  1.69   DIST=      2.0000
?      11 13
   SW  71- 39-  1.69   DIST=      2.0000
?      11 12
   NW  48- 20- 58.31   DIST=      7.5056
?      13 14
   NW  48- 20- 58.31   DIST=      7.5056
?      6 8
   SW  71- 39-  1.69   DIST=    153.0000
?      7 9
   SW  71- 39-  1.69   DIST=    153.0000
?      4 2
   SW  71- 39-  1.69   DIST=     75.5000
?      4 1
   SW  71- 39-  1.69   DIST=     76.5000
?      1 5
   SW  71- 39-  1.69   DIST=     76.5000
?      3 5
   SW  71- 39-  1.69   DIST=     75.5000
?      0 0
```

Geometry - Spur Line Bridge

Cy: RSM 3-...
Chkd: DLt 12-3-...

PT Sta 114+57.58
(+) 2.26

℄ Brgs Abut #1 Sta 114+59.84
(+) 76.50

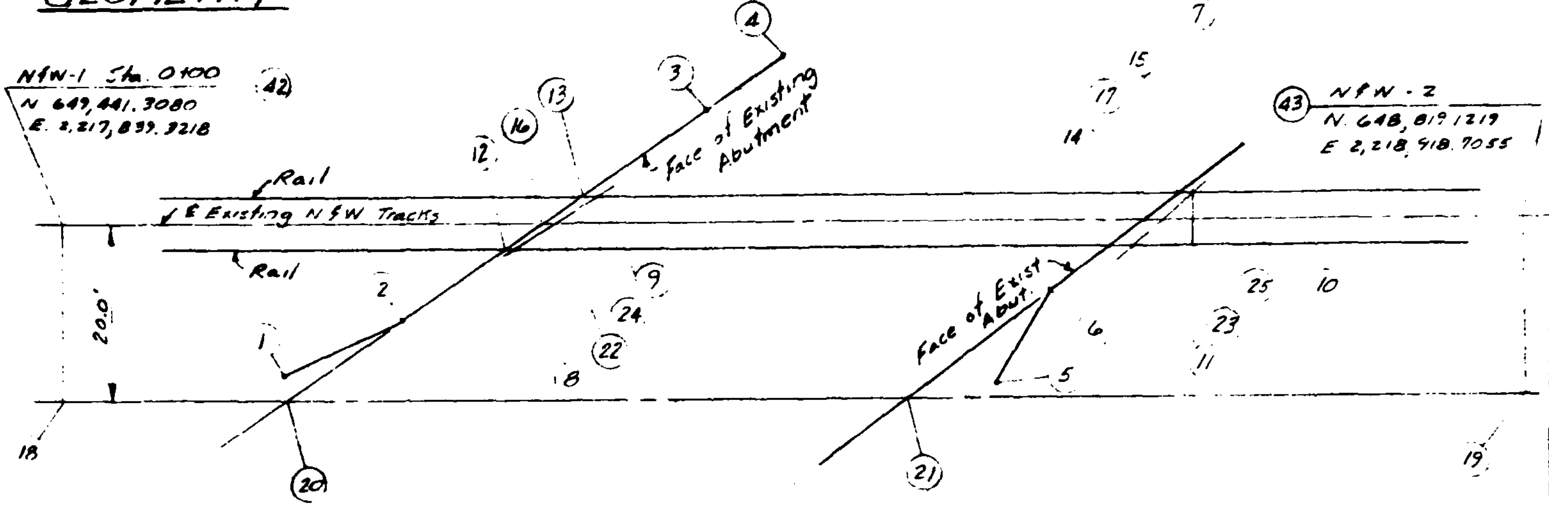
℄ Pier Sta 115+36.34
(+) 76.50

℄ Brgs Abut #2 Sta 116+12.84

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Cleveland Flood Control Project FILE NO.
Ma[illegible] Bridge SHEET NO. ___ OF ___ SHEETS
FOR
COMPUTED BY ΔSM DATE [illegible]-2-79 CHECKED BY [illegible] DATE [illegible]-6-79

GEOMETRY



D2-7

From Survey :

⊼ at Mon. 110 (40)

N. 649,008.78
E 2,218,363.99

Backsight to Mon. 121 (41)

N. 649,106.18
E. 2,218,409.23

Turn To	Clockwise ∡	Distance
1	348°-10'-40"	89.01
2	10-46-20	102.06
3	24-36-58	132.83
4	27-53-40	144.70
5	44-55-35	110.60
6	43-23-15	133.34
7	45-53-37	159.85
8	16-59-50	112.67
9	20-29-04	119.68
10	45-35-58	151.97
11	45-03-40	143.60

Existing N+W Bridge
By: ESN 12-2-7?
Chkd: DL 3-8-7?

edit (file) ...
EDIT ...

COMMAND
? ...
? 1 99 11
? 0 0 0

COMMAND:
? ...
? 40 649008.7800 2218363.9900 Mon. 110
? ~~41 649106.1800 2218409.2~~
? 41 649106.1800 2218409.2300 Mon. 121
? 42 649441.3080 2217839.3218 N+W-1
? 43 648819.1219 2218918.7055 N+W-2
? 0 0 0

COMMAND:
? lan
~~? 41 40 1 89.01 34810 40~~
~~? 0~~
~~1 649017.4356 2218275.4018~~
? 41 40 1 89.01 348 10 40
1 649095.4766 2218384.1514
? 41 40 2 102.06 10 46 20
2 649091.6758 2218423.5259
? 41 40 3 132.83 24 36 58
3 649094.9935 2218465.0397
? 41 40 4 144.70 27 53 40
4 649096.2490 2218479.2604
? 41 40 5 110.60 44 55 35
5 649046.8972 2218467.8141
?

2

Existing N & W Bridge

by: RSM (2-2-79)

chkd: DLH (2-8-79)

```
      41 40 6 133.34  43 23 15
  6   649058.0793 2218487.8816
?     41 40 7 159.85  45 53 37
  7   649061.3299 2218514.9553
?     41 40 8 112.67  16 59 50
  8   649092.6272 2218439.2508
?     41 40 9 119.68  20 29 04
  9   649092.8164 2218449.2026
?     41 40 10 151.97  45 35 58
 10   649059.4756 2218507.2549
?     41 40 11 143.60  45 03 40
 11   649057.9533 2218498.9083
?     0 0 0 0 0 0 0

COMMAND:
?     pin
?     12 8 11 2 3
 12   649092.8956 2218438.7889
?     13 9 10 2 3
 13   649093.6165 2218447.8094
?     14 8 11 6 7
 14   649059.1550 2218496.8407
?     15 9 10 6 7
 15   649060.2446 2218505.9160
?     16 42 43 2 3
 16   649093.2442 2218443.1513
?     17 42 43 6 7
 17   649059.6965 2218501.3508
?     22 42 43 8 9
 22   649092.7186 2218444.0632
?     23 42 43 10 11
 23   649058.7107 2218503.0610
?     0 0 0 0 0

COMMAND:
?
```

D2-9

```
      pin
?     42 43 29.0 18 19
 18  649423.9906 2217929.3338
 19  648801.7945 2218908.7175
?     0 0 0 0 0

COMMAND:
?     tot
?     24 9 8 11
 24  649088.3513 2218446.6075
?     25 10 8 11
 25  649054.7115 2218504.4859
?     0 0 0 0

COMMAND:
?     pin
?     20 18 19 2 3
 20  649090.4334 2218407.9796
?     21 18 19 6 7
 21  649055.7170 2218468.2064
?     0 0 0 0 0

COMMAND:
?     ibr
?     2 3
   NE  85- 25- 50.65   DIST=      41.6461
?     6 7
   NE  83-  9- 12.78   DIST=      27.2681
?     8 9
   NE  88- 54- 39.26   DIST=       9.9537
?     11 10
   NE  79- 39- 48.26   DIST=       8.4843
?     9 10
   SE  60-  7- 49.00   DIST=      66.9453
?     8 11
   SE  59- 50-  3.07   DIST=      69.0022
?
```

Existing N & N Bridge

by: RSM (2-2-79)
chkd: DCH (2-8-79)

3

D2-10

```
    13 15
SE  60-  7- 49.00   DIST=      67.0079
?   16 17
SE  60-  2- 22.86   DIST=      67.1761
?   12 14
SE  59- 50-  3.07   DIST=      67.1449
?   9 13
NW  60-  7- 49.00   DIST=       1.6066
?   22 16
NW  60-  2- 22.86   DIST=       1.0525
?   8 12
NW  59- 50-  3.07   DIST=       0.5342
?   15 10
SE  60-  7- 49.00   DIST=       1.5441
?   17 23
SE  60-  2- 22.86   DIST=       1.9740
?   14 11
SE  59- 50-  3.07   DIST=       2.3914
?   2 20
SW  85- 25- 50.65   DIST=      15.5959
?   6 21
SW  83-  9- 12.78   DIST=      19.8165
?   42 16
SE  60-  2- 22.86   DIST=     696.9638
?   42 17
SE  60-  2- 22.86   DIST=     764.1399
?   18 20
SE  60-  2- 22.86   DIST=     667.8957
?   18 21
SE  60-  2- 22.86   DIST=     737.4119
?   20 21
SE  60-  2- 22.86   DIST=      69.5161
?   16 20
SW  85- 25- 50.65   DIST=      35.2838
?   16 2
SW  85- 25- 50.65   DIST=      19.6880
?
```

Existing N&W Bridge

by: REM (2-2-79)
chkd: [illegible] ([illegible]-8-79)

Existing N & W Bridge

by: RSM (2-2-79)

chkd: DGH (2-2-79)

```
    17 21
  SW  83-  9- 12.78   DIST=     33.3824
?   17 6
  SW  83-  9- 12.78   DIST=     13.5659
?   9 24
  SW  30-  9- 56.93   DIST=      5.1644
?   10 25
  SW  30-  9- 56.93   DIST=      5.5104
?   9 22
  SW  88- 54- 39.26   DIST=      5.1404
?   22 8
  SW  88- 54- 39.26   DIST=      4.8133
?   13 16
  SW  85- 25- 50.65   DIST=      4.6729
?   16 12
  SW  85- 25- 50.65   DIST=      4.3763
?   13 12
  SW  85- 25- 50.65   DIST=      9.0493
?   15 17
  SW  83-  9- 12.78   DIST=      4.5980
?   17 14
  SW  83-  9- 12.78   DIST=      4.5425
?   15 14
  SW  83-  9- 12.78   DIST=      9.1404
?   10 23
  SW  79- 39- 48.26   DIST=      4.2631
?   23 11
  SW  79- 39- 48.26   DIST=      4.2212
?   2 6
  SE  62- 26-  0.46   DIST=     72.5974
?   0 0
```

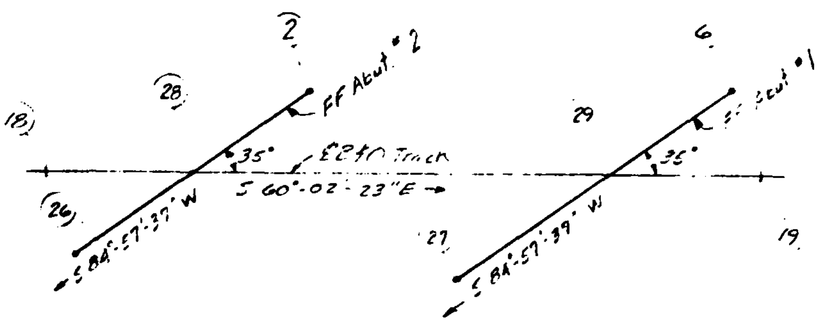
```
COMMAND
?      ang
?      9 8 11
  31- 15- 17.67     DIST  8 TO  11=     69.0022
?      9 22 43
  31-  2- 57.88     DIST 22 TO  43=    547.8508
?      3 13 10
  34- 26- 20.35     DIST 13 TO  10=     68.5519
?      3 16 43
  34- 31- 46.49     DIST 16 TO  43=    548.9033
?      3 12 11
  34- 44-  6.28     DIST 12 TO  11=     69.5364
?      7 15 10
  36- 42- 58.22     DIST 15 TO  10=      1.5441
?      7 17 43
  36- 48- 24.36     DIST 17 TO  43=    481.7272
?      7 14 11
  37-  0- 44.15     DIST 14 TO  11=      2.3914
?      10 23 43
  40- 17- 48.88     DIST 23 TO  43=    479.7532
?      10 11 25
  40- 30-  8.67     DIST 11 TO  25=      6.4513
?      3 20 19
  34- 31- 46.49     DIST 20 TO  19=    577.9713
?      7 21 19
  36- 48- 24.36     DIST 21 TO  19=    508.4552
?      20 2 1
  10-  4- 58.29     DIST  2 TO   1=     39.5575
?      5 6 21
  22- 16- 51.74     DIST  6 TO  21=     19.8165
?      0 0 0
```

Existing 11th W Bridge

by: RSM (2-2-79)
chkd: [illegible] (2-8-79)

```
        ibr
?       2 26 150.0 3 84 57 37
 26   649078.4989 2218274.1058
?       6 27 150.0 3 84 57 37
 27   649044.9024 2218338.4615
?       0 0 0 0 0 0 0

COMMAND:
?       pin
?       28 18 19 2 26
 28   649090.3219 2218408.1731
?       29 18 19 6 27
 29   649056.2610 2218467.2627
?       0 0 0 0 0

COMMAND:
?       ibr
?       28 29
   SE  60-  2- 22.86   DIST=      68.2036
?       18 28
   SE  60-  2- 22.86   DIST=     668.1190
?       29 19
   SE  60-  2- 22.86   DIST=     509.5444
?       0 0

COMMAND:
?       eoi

END OF PROGRAM COG

EDIT  end
```

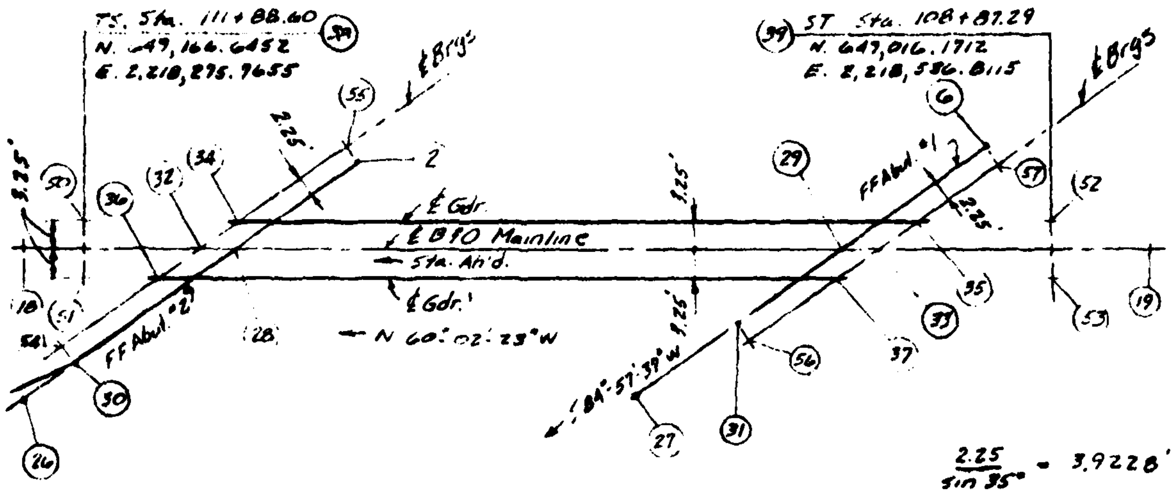
Note: Tie new B&O Structure to
Existing N&W Abuts. as follows:
by: RSM (2-2-79)
chkd: DH (2-6-79)



GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Clevel[illegible]a Flood Control Project — Mainline Bridge
FILE NO. ____ SHEET NO. ____ OF ____ SHEETS
FOR ____
COMPUTED BY KSM DATE 2-2-79 CHECKED BY [illegible] DATE [illegible]-5-79

GEOMETRY



$\frac{2.25}{\sin 35^\circ} = 3.9228'$

Skew ∡ = 35°-00'-00"
Pt (30) = Bend Pt. of Wing
Pt (31) = ℄ ½" Jt.

From Abut. Dwgs:
Dist. 32 to 54 = 24'-11"
do 33 to 56 = 13'-4½"

8818

Main Line B&O Bridge

Geometry

by : RJM (2-2-79)

chkd : DLH (2-8-79)

```
      edit cl(-oq) iel,
EDIT  run

COMMAND
?     cl,
?     1 -?? 1
?     0 0 0

COMMAND
?     slr
?     2  649091.6758  2218423.5259
?     5  649058.0793  2218487.8816
?     18 649423.9806  2217829.3338
?     19 648801.7945  2218908.7175
?     26 649078.4989  2218274.1058
?     27 649044.9024  2218338.4615
?     28 649090.3219  2218408.17[3]31 (Call OK)
?     29 649056.2610 2218467.2627
?     38 649164.6452 2218275.7655
?     39 649016.1712 2218536.8115
?     0 0 0

COMMAND:
?     ibr
?     19 18
   NW  60-  2- 22.86   DIST=    1245.8671
?     39 38
   NW  60-  2- 22.86   DIST=     301.3095
?     0 0

COMMAND:
?     ibr
?     19 39
   NW  60-  2- 22.87   DIST=     429.2685
?     0 0

COMMAND:
?
```

Mainline B & O Bridge
by: RSM (2-2-79)
chkd: DLH (2-8-79)

```
?      lan
?      28 2 55 2.25 90 00 00
 55   649093.9171 2218423.3283
?      29 6 57 2.25  270 00 00
 57   649055.8380 2218488.0793
?      0 0 0 0 0 0 0

COMMAND:
?      lln
?      28 38 32 3.9228
 32   649092.2810 2218404.7727  ← ℄ Brgs, Abut #2
?      29 39 33 3.9228
 33   649054.3020 2218470.6613  ← ℄ Brgs. Abut #1
?      32 55 54 -24.9167
 54   649090.0924 2218379.9523
?      33 57 56 -13.3438
 56   649053.1297 2218457.3691
?      0 0 0 0

COMMAND:
?      lan
?      55 54 30 2.25 90 00 00
 30   649087.8511 2218380.1499
?      57 56 31 2.25 270 00 00
 31   649055.3710 2218457.1714
?      0 0 0 0 0 0 0

COMMAND:
?      pln
?      39 38 3.25 52 50
 52   649018.9869 2218538.4346
 50   649169.4609 2218277.3886
?      38 39 3.25 51 53
 51   649163.8295 2218274.1424
 53   649013.3555 2218535.1884
?      0 0 0 0 0
```

Ma[illegible] 3[illegible] B[illegible]
by: RSM (2-2-79)
chk'd: [illegible] 2-8-[illegible]

COMMAND
? pin
? 44
50 53 54 55
34 649092.7238 2218410.4186
? 35 50 52 56 57
45 649054.7997 2218476.3056
? 36 51 53 54 55
36 649091.7844 2218399.1298
? 37 51 53 56 57
37 649053.8042 2218465.0170
? 0 0 0 0 0

COMMAND
? inv
? 39 33
NW 60- 2- 22.90 DIST= 76.3531
? 39 32
NW 60- 2- 24.01 DIST= 152.4039
? 35 34
NW 60- 2- 22.86 DIST= 76.0494
? 33 32
NW 60- 2- 25.12 DIST= 76.0507
? ~~37 38~~ 37 36 76.0496
~~NW 59- 11- 40.35 DIST= 220.3389~~
? 57 33
SW 84- 57- 36.97 DIST= 17.4855
? 33 56
SW 84- 57- 36.97 DIST= 13.3438
? 55 32
SW 84- 57- 39.50 DIST= 18.6276
? 32 54
SW 84- 57- 39.50 DIST= 24.9167
? 34 32
SW 84- 57- 39.50 DIST= 5.6678
? ~~32 36~~
~~SW 84- 57- 39.50 DIST= 5.6648~~
~~? 34 36~~
~~SW 84- 57- 39.50 DIST= 11.3326~~
?

℄ Brgs Abut #1 = Sta. 109+63.64
℄ Brgs Abut #2 = Sta. 110+39.69

Span Length = 76'-0 5/8"

D2-18

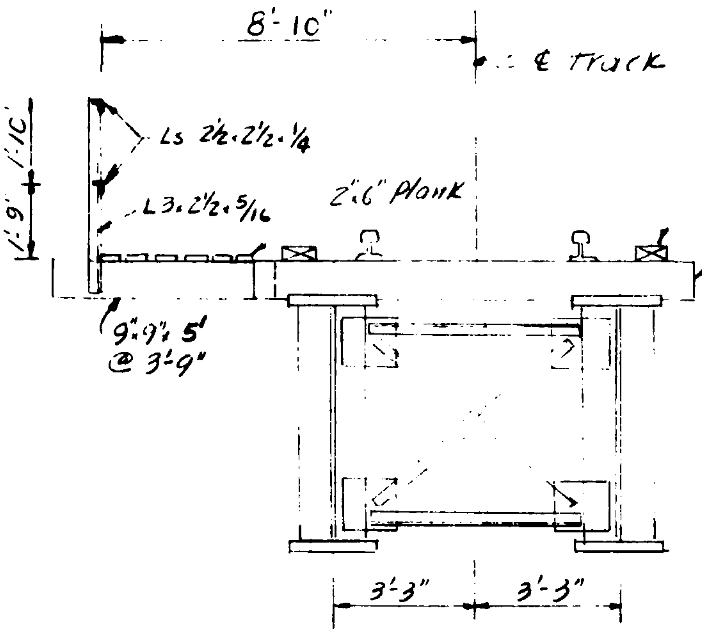
```
        32 36
    SW  84- 57- 39.50   DIST=        5.6648
?       34 36
    SW  84- 57- 39.50   DIST=       11.3326
?       35 33
    SW  84- 57- 36.97   DIST=        5.6662
?       33 37
    SW  84- 57- 36.97   DIST=        5.6662
?       35 37
    SW  84- 57- 36.97   DIST=       11.3324
?       29 31
    SW  84- 57- 36.41   DIST=       10.1304
?       28 30
    SW  84- 57- 39.55   DIST=       28.1301
?       0 0

COMMAND:
?       eoi

END OF PROGRAM COG

EDIT  end
```

Mainline B&O Bridge

by: RSM (2-2-79)
chkd: DH (2-8-79)

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Big Creek R.R. Bridge FILE NO.
Main Line SHEET NO. OF SHEETS
FOR U.S Army Engineer District - Buffalo
COMPUTED BY JKS DATE 12-13-78 CHECKED BY RSM DATE 1-2-79



TYPICAL SECTION

SPAN LENGTH = 78'
(C/C Bearings)

Design specifications:
AREA (1975)
Structural welding code:
AWS D1.1 Rev. 2-77

Dead Load:

1) Track and sidewalk:

Wt of track rails, guard rails, etc	= 200 #/'
Timber guard rail = 0.33×0.67×60×2	= 27
Ties = 0.75×0.75×10'×60÷1.25	= 270
0.75×0.75×5'×60÷3.75	= 45
Planks = 0.17×0.5×6×60	= 64
railing = L2½·2½·¼ = 4.1×2	= 8
L 3×2½×5/16 : 5.6×4.33÷3.75	= 6
	620 #/'

2) Steel: * For DL computation only

Web: 64×½" : 109×2	= 218
Flanges 24×2⅝ : 214×4	= 856
Transv. Stiff: 8×½ @ 4'(±) 13.6×5.33×4÷4	= 72
Diaphragms: L3½×3½×½(*): 11.1×4.75×2 = 105	
L3½×3½×½(*): 11.1×5.75×2 = 128	
Conn. Pls: 15×½×12 = 25.5×4 = 102	
335 ÷ 15.6 =	21
Lateral bracing: L3½×3½×½(*) 11.1×10×2×2 ÷ 15.6	= 28
	1195 #/'

Total DL = 1.815 k/'

Per Girder = 0.91 k/'

D2-20

6318

Live Load: Cooper E-80

Impact : Diesel impact and open-deck bridge

$$I = \frac{100}{S} + 40 - \frac{3L^2}{1600}$$

$S = 6.5'$ $L = 78'$ $I = 44\%$

Moments and shears for Cooper's E-50 : table 3 Page 144
(Stresses in framed structures)
Hool & Kinne (McGraw Hill)

Max Moments:		Max. Shears:	
$DL = 0.910 \times \overline{78}^2 \div 8$	$= 692$	$0.910 \times 78 \div 2 =$	35
$LL = 2581 \times \frac{80}{50}$	$= 4130$	$152 \times \frac{80}{50}$	$= 243$
$I = 4130 \times 0.44$	$= 1817$	243×0.44	$= 107$
	$6639^{k\text{-}1}$		385^k

Use A36 Steel.

Allow Shear in Web = 12.5 ksi

Max shear stress = $385 \div (64 \times 1/2) = 12.0$ ksi

$I = I_w + d^2A \times 2$ ← (2 Flanges) *

Max bending stresses : $I = \frac{64^3 \times 0.5}{12} + \overline{33.25}^2 \times 24 \times 2.5 \times 2 = 143{,}591\ in^4$

$S = 4162$ $f_s = \frac{6639 \times 12}{4162} = 19.14$ ksi (increase flange size see LL+I deflection)

Allow. compressive stress: Diaphragm spacing = 17.5'

$A_1 = \frac{64}{2} \times 0.5 + 24 \times 2.5 = 76\ in^2$

$I_1 = \frac{24^3 \times 2.5}{12} + \frac{64}{2} \times \frac{\overline{0.5}^3}{12} = 2880\ in^4$ $r_y = 6.16''$

$\frac{L}{r} = \frac{17.5 \times 12}{6.16} = 34 < 157$

$F_b = 20000 - 0.4(34)^2 = 19535$ psi

or $\frac{10500000}{17.5 \times 12 \times 69/24 \times 2.5} = 43478$ psi

Use 20.0 ksi

$\boxed{\text{* For Detailed Breakdown, See Sheet D2-21a}}$

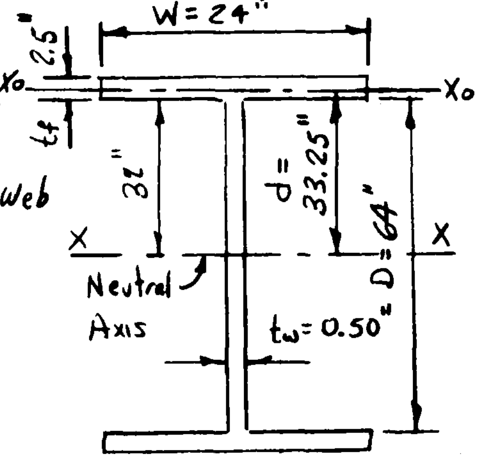
Deflection: Use Live load + Impact

allow = $L/640 = 1.46''$

8815

MOMENT OF INERTIA OF GIRDER

Reference Sheet D2-21 where Moment of Inertia of Girder computed at 143,591 $IN.^3$ The following is a detailed breakdown for determining this value.



I = Moment of Inertia of Girder
$I = I_W + I_{FT} + I_{FB}$
I_W = Moment of Inertia of Web
I_{FT} = Moment of Inertia of Top Flange
I_{FB} = Moment of Inertia of Bottom Flange

$$I_W = \frac{1}{12} \times t_w \times D^3$$
$$= \tfrac{1}{12} \times 0.50 \times 64^3 = 10{,}922.67 \text{ IN.}^3$$

$$I_{FT} = I_{FB} = A \times d^2$$
$$A = 2.5 \times 24 = 60.0 \text{ IN.}^2$$
$$d = 32.00 + \tfrac{1}{2} t_f = 32.00 + \tfrac{1}{2} \times 2.5$$
$$d = 32.00 + 1.25 = 33.25"$$
$$I_{FT} = I_{FB} = 60 \times 33.25^2 = 66{,}333.75 \text{ IN.}^3$$

$$\therefore I = 10{,}922.67 + 66{,}333.75 + 66{,}333.75$$
$$I = 143{,}590.17 \text{ IN.}^3$$

NOTE: Theoretically, I_{FT} & $I_{FB} = I_{X_o} + Ad^2$
I_{X_o} = The moment of inertia of the flange with respect to its parallel centroidal axis (X_o)
$I_{X_o} = \tfrac{1}{12} \times W \times t_f^3 = \tfrac{1}{12} \times 24 \times 2.5^3 = 31.25 \text{ IN.}^3$
$\therefore I = 143{,}590.17 + 31.25 + 31.25 = 143{,}652.67 \text{ IN.}^3$
% Error in neglecting I_{X_o} = 0.04%
I_{X_o} is neglected because it is negligable.

```
      edit dfl ipli
EDIT  run
SPAN(FT).WL(KIP/FT).WR(KIP/FT).ML(FT-KIP).MR(FT-KIP)
?      78 5.76 5.76 0 0
START & END OF UNIFORM LD?
?      74.54 78
NO. OF "I" VALUES?
?      1
DISTANCE & "I"?
?      78 143591
NO. OF CONC. LDS.?
?      12
LOAD & DISTANCE?
?      37.44 2.54  37.44 8.54
?      37.44 13.54  28.8 21.54
?      57.6 29.54  57.6 34.54
?      57.6 39.54  57.6 44.54
?      37.44 53.54  37.44 58.54
?      37.44 64.54  37.44 69.54

            DEFLECTION (INCHES)
  .10 PT   .20 PT   .30 PT   .40 PT   .50 PT
  0.4663   0.8847   1.2164   1.4309   1.5053

  .60 PT   .70 PT   .80 PT   .90 PT
  1.4316   1.2190   0.8880   0.4682

            ROTATIONS(RAD.)
LEFT=  0.0050741     RIGHT= -0.0050917

DIST. TO SPECIAL POINT?
?      0

END OF PROGRAM DFL
EDIT  end
```

Live Load Deflection
B & O Mainline

BY: JRS (12-13-78)
CHKD: RSM (1-3-79)

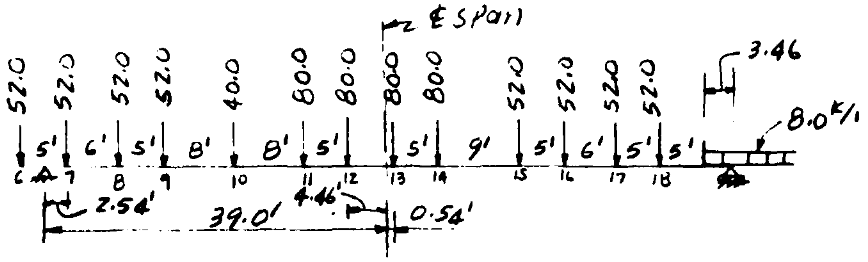
NOTE:
This sheet is the output from a Deflection Program. Writeup of this program at end of this Subappendix.

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT: Big Creek R.R. Bridge — FILE NO. ____
Main Line — SHEET NO. ____ OF ____ SHEETS
FOR ____
COMPUTED BY: JRS DATE: 12-13-78 CHECKED BY: KSM DATE: 1-4-79

Deflection (cont.)

Locate Wheel 13 at 0.54' Rt of ℄ span:



Load per Girder: (include impact)

$\frac{52}{2} \times 1.44 = 37.44^k$ $\quad \frac{80}{2} \times 1.44 = 57.60^k$

$\frac{40}{2} \times 1.44 = 28.80^k$ $\quad \frac{8}{2} \times 1.44 = 5.76^{k/1}$

run program DFL

Max deflection $1.51 > \Delta_{allow}$

increase flange Ps by 1/8":

$I = \frac{64^3 \times 0.5}{12} + 33.31^2 \times 24 \times 2.625 \times 2 = 150727 \text{ in}^4$

$S = 4353$

Max deflection $= 1.51 \times \frac{143591}{150727} = 1.44'' < L/640$ ok

Max. stresses $= 6639 \times 12 \div 4353 = 18.3$

Use 64"×1/2" Web and 24"×2 5/8" Flanges

Intermediate stiffeners:

$D/t = 64/0.5 = 128 > 60$ use stiffeners

Max S = 12.5 ksi $\quad$ Spacing $= \frac{10500 \times 0.5}{\sqrt{12500}} \approx 47''$

Max shear at 1/4 point:

$V_{DL} = 35.0 - 19.5 \times 0.91 = 17^k$

$V_{LL+I} = 88.2 \times \frac{80}{50} \times 1.44 = 203$ $\quad V_{Total} = 220^k$

$S = 6.88$ ksi $\quad d = \frac{10500 \times 0.5}{\sqrt{6880}} = 63''$

Stiffener Size: use 1/2" Max width $= 16 \times \frac{1}{2} = 8''$ say 8"×1/2" (pairs)
or $2'' + \frac{69.25}{30} = 4.3$

Stiffener on one side only: I of 2 stiff $\approx \frac{16^3 \times 0.5}{12} = 171$

I of one stiff $= \frac{h^3}{3} \times \frac{h}{16} = 171$ $\quad h \approx 9.5''$ $\quad t = 5/8$ say 9 1/2 × 5/8 (one side only)

D2-23

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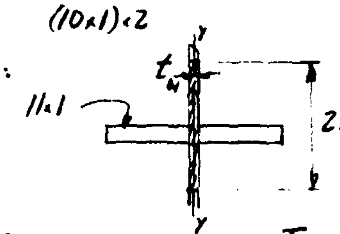
Bearing Stiffeners: Max reaction = 385^k
try 11" Ps: Min $t = W/12 = 1"$

check bearing: $\frac{385}{(10\times1)\times2} = 19.25 < 30.0$ ok

Compressive stress:



$A = 11\times1\times2 + 12.5\times0.5 = 28.25$

$I_y = \frac{1\times\overline{11}^3}{12}\times2 + 11\times1\times2\times\overline{5.75}^2 + \frac{12.5\times\overline{0.5}^3}{12} = 949.3$

$r = 5.8$

$\frac{KL}{r} = \frac{0.75\times64}{5.8} = 8.3 < 15$ use $F_a = 20.0$ ksi

Max stress $= \frac{385}{28.25} = 13.63$ ksi ok

Stiffener to web connection:
allow. shear in fillet welds = 12.5 ksi
tickness $= \frac{385}{2\times64\times2\times0.707\times12.5} = 0.17$ Use 5/16" (Min. size)

Fatigue: Use 500000 cycles Use AWS criteria
Attachment for lateral bracing: use Category E
(see Fig 9.4b AWS D.1) stress range $F_{sr} = 12.5$ ksi (*)
assume Welding @ 5" from bot. of web: $S = \frac{150727}{27} = 5582$
Max stresses $= \frac{6639\times12}{5582} = 14.27$
Min stress (DL only) $= \frac{692\times12}{5582} = 1.49$ * By AASHTO $F_{sr} = 8.0$ ksi
Stress range = 12.78
Use bolted connection
Transvera Stiffeners: $F_{sr} = 20.0$ ksi

Lateral bracing and diaphragms:
Wind load: 1) on loaded bridge = 300 #/' (8' above top of rail)
2) on bridge = 30 #/SF $\times \frac{69}{12} = 172$ #/' $\times 1.5 = 258$ #/'

Lateral force from equipment: $\frac{1}{4}\times80 = 20.0^k$

Bracing between compression members: $0.025\times20.0\times24\times2.625 = 31.5^k$
Assume Max stresses

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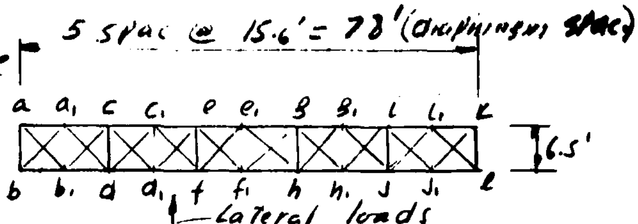
a) Lateral bracing:
assume 90° skew bridge



Top & bot. flange Lateral bracing

Use a lateral truss placed in the plane of the top flange in order to resist all the Lateral loads. Assume that diagonals take both Tension and Compression and that they are both in action, each taking $\frac{1}{2}$ the shear on the section.

Wind load per panel $= (300 + \frac{258}{2}) \times \frac{15.6}{2} = 3.35^k$

$V_{ab} = 3.35 \times \frac{10}{2} = 16.7^k$

Lateral load from equipment: applied at panel bd

$V_{ab} = 20^k$

Max $V_{ab} = 37^k$ $\quad ba_1(\text{length}) = (6.5^2 + 7.8^2)^{1/2} = 10.2'$

Force on $ba_1 = \frac{37}{2} \times \frac{10.2}{6.5} = 29^k$ (*) Note: Use L $3\frac{1}{2} \times 3\frac{1}{2} \times \frac{3}{8}$ (Min Size Material = 0.375")

Try L $3\frac{1}{2} \times 3\frac{1}{2} \times \frac{5}{16}$(*) $A = 2.09\ in^2$ $r = 0.69$

allow stresses: Use $L = 4.2'$ $K = 3/4$ $\frac{KL}{r} = \frac{4.2 \times 12 \times 0.75}{0.69} = 55 < 75$

$F_a = 21500 - 100 \times 55 = 16000$ psi

$f_a = 29 \div 2.09 = 13.8$ ksi ok

bolts connection: Use $7/8"\phi$ H.S. Bolts

neglect fatigue. load per bolt $= 0.875^2 \times \frac{3.14}{4} \times 20 = 12.0^k$

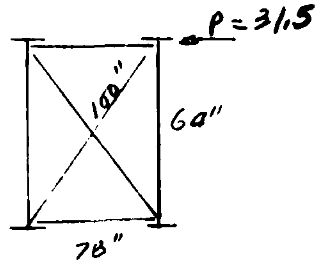
# of bolts required $= 29 \div 12 = 2.4$ Use 3. (*)

* Weld required $= 29 \div (12.5 \times \frac{1}{4} \times 0.707) = 13"$

b) Intermediate diaphragms: Use cross frames to brace top flange and Stiffen the bot. flange. Each diagonal is assumed to take $\frac{1}{2}$ of the horizontal Shear (Tension and Compression at the same time) D2-25

0919

Diaphragms (Cont.)



F(diagonal) $= \frac{31.5 \times 100}{78 \times 2} = 19^k$

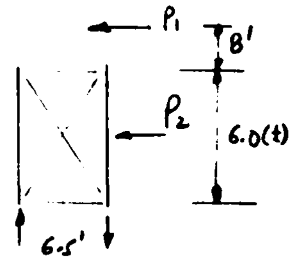
F(Horizontal) = 15.75
$L = 68''$ $\frac{KL}{r} = 74$
$F_a = 21500 - 100 \times 74 = 14100$

Try $L\,3\frac{1}{2} \times 3\frac{1}{2} \times \frac{5}{16}$: $A = 2.09$ $r = 0.69$ $L = 50''$ $\frac{KL}{r} = 54$ (diagonal)
$F_a = 21500 - 100 \times 54 = 16100$
$f_a = 19 \div 2.09 = 9.1$ ksi ok. Use $L\,3\frac{1}{2} \times 3\frac{1}{2} \times \frac{3}{8}$
# of bolts $= 19 \div 12 = 1.6$ Say 3 Min Weld $= 19/12.5 \times 0.707 \times \frac{1}{4} = 9''$

End diaphragms: provide end cross frames to carry all lateral forces to the supports on the Abutments.

Wind load $= 16.7^k$
Lateral load $= \underline{20.0^k}$
36.7^k (applied ⊥ to ℄ Girder)

For end diaphragm design see next sh.



Chek Stability:
$LL = 1200^{\#/\prime}$
Vertical reaction per Girder: $DL = 35^k$
$LL = \frac{1.2}{2} \times 78 \div 2$ (No impact) $= 24^k$
Horizontal reactions:
Wind on LL $= 0.3 \times 78 \div 2 = P_1 = 11.7^k$ (@ 8' above top of rail)
Wind on structure $= 0.258 \times \frac{78}{2} = P_2 = 10.0^k$
Overturning moment $= 11.7 \times 14.0 + 10.0 \times 3 = 194^{k\text{-}\prime}$
Vertical reaction $= \pm \frac{194}{6.5} = 30.0^k$

Min reaction $= 35 + 24 - 30 = 29^k$ No uplift

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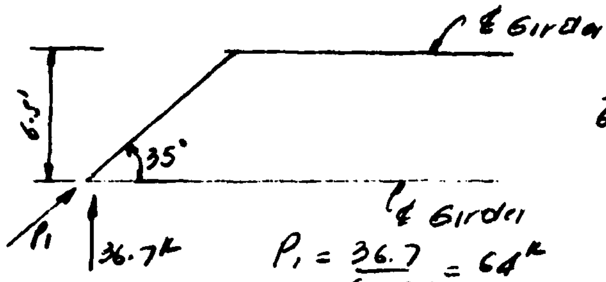
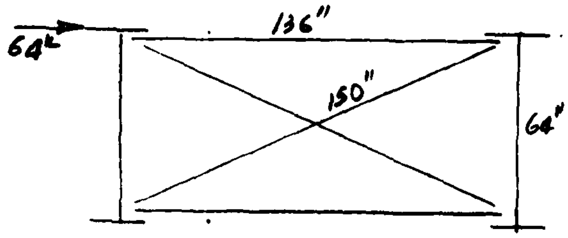
End diaphragm (cont.)



$P_1 = \frac{36.7}{\sin 35^\circ} = 64^k$



Force Diagonal $= 32 \times \frac{150}{136} = 35.3^k$

Strut:

Max $\frac{KL}{r} = 120$ $l = 136 - 12 = 124''$

try $\angle 4 \times 4 \times 1/2$: $r = 0.782''$ $A = 3.75\ \square''$

$\frac{KL}{r} = \frac{0.75 \times 124}{0.782} = 119$ ok

$F_a = 21500 - 100 \times 119 = 9.6$ ksi

$f_c = 32 \div 3.75 = 8.53$

Weld. length $= \frac{9.6 \times 3.75}{12.5 \times 0.707 \times 1/4} = 16.3''$

Use $\angle 4 \times 4 \times 1/2$

Diagonal:

Try $\angle 3\frac{1}{2} \times 3\frac{1}{2} \times 3/8$ $A = 2.48$ $r = 0.687$

$\frac{KL}{r} = \frac{0.75 \times (75-12)}{0.687} = 68.8 < 120$

$F_a = 14.62$ ksi

$f_c = \frac{35.3}{2.48} = 14.23$ ksi ok

Use $\angle 3\frac{1}{2} \times 3\frac{1}{2} \times 3/8$

$l_{weld} = 14.5 \times \frac{35.3}{32} = 16''$

No. of bolts $= \frac{35.3}{12} = 3$ bolts.

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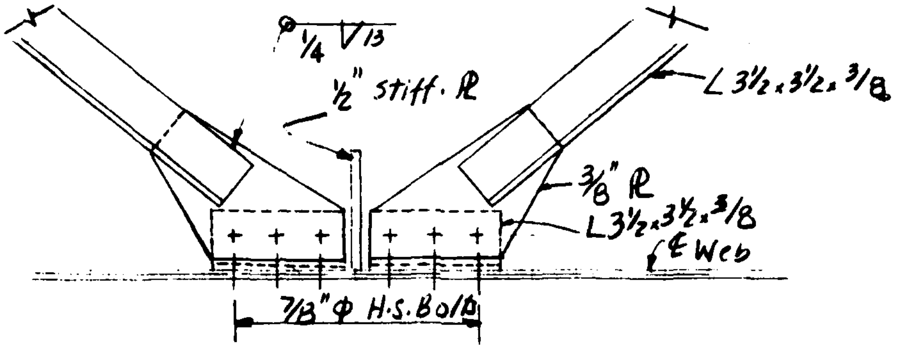
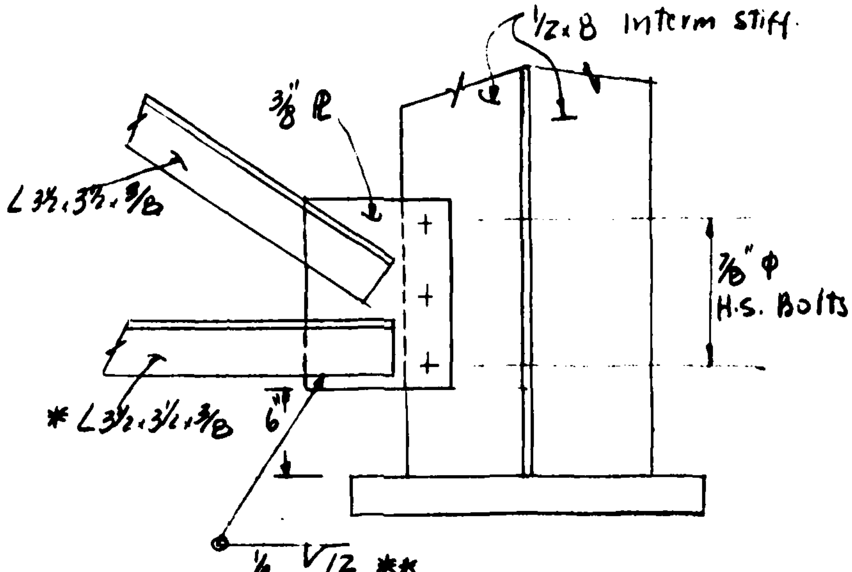


Lateral Bracing Connection
Scale 1" = 1'0"



Typ. Diaphragm Connection
Scale 1" = 1'-0"

* Use L 4 x 4 x 1/2 End diaphragm.
** Use 16" of 1/4" fillet weld for end diaphragm.

D2-28

6818

Bearing Shoes:

Max Reaction $= 385^k$ Flange Width $= 24''$

Allow bearing between rockers and rocker pin $= 13.5$ ksi

Allow bearing on rockers $= 690\,d$ for $d < 25''$

1) Expansion Shoe: $= 3450\sqrt{d}$ $25'' < d < 125''$

Min length (pin) $= \dfrac{385}{3 \times 13.5} = 9.5''$ (try 3" diameter) use $3''\phi \times 28''$

Allow bearing on steel parts in contact $= 30.0$ ksi

Min size of Web $P\!\!\!L = \dfrac{385}{3 \times 30} = 4.3''$ use $28'' \times 3''$

Bearing on rocker: use $R = 15''$

$d = 30''$ Allow. bearing $= 3450\sqrt{30} = 18900\ \#/in$

Min length $= \dfrac{385}{18.9} = 20.3''$ use $30''$

Max effective length $= 28 + (15 - 1.5) = 41.5'' < 20.3''$

$W_{TOP} - W_{bot} \le 2h$ $12 - 1.5 = 10.5 < 2 \times 15$ radius

Masonry $P\!\!\!L$:

Expansion: use $1''$ per $100'$ or $e_{cc} = 1.0 \times \dfrac{79}{100} = 0.79''$

$M = 0.79 \times 385 = 304^{k\text{-}in}$

Max effective length $= 41.5$

effective width $= 4t$

Allow bearing pressure $= 0.25 f'_c$ use $f'_c = 3000$ psi

$= 0.25 \times 3000 = 750$ psi

try $t = 4''$ $\therefore b = 4 \cdot 4.0 = 16$

$p_{max} = \dfrac{385}{41.5 \times 16} \pm \dfrac{304}{41.5 \times \frac{16^2}{6}} = 0.580 \pm 0.171 = 0.751 \simeq 0.75$ ok.

Check thickness: $p_{max} = 0.751$ $p_{\mathcal{E}} = 0.580$

$p_{min} = 0.409$

$M = 0.580 \times \dfrac{8^2}{2} + 0.171 \times \dfrac{8}{2} \times \dfrac{2}{3} \times 8 = 22.2^{k\text{-}in}/in$ $t = \left(\dfrac{22.2 \times 6}{20}\right)^{1/2} = 2.6$

Use $44'' \times 16'' \times 4''$ Masonry $P\!\!\!L$

Check bearing on pintles: $F_{lateral} = 11.7 + 10.0 + 20.0 = 41.7 \div 2 = 21^k$ per shoe

bearing $= \dfrac{21}{2 \times 1 \times 1} = 10.5\ K/in^2$

Use 2 pintles ($1\tfrac{1}{2}''\phi$)

Shear $= \dfrac{21.0}{\pi/4 \times 1.5^2 \times 2} = 11.9 < 15.0$ (allow. shear on pins)

Bearing Shoes (Cont.)

Bearing Stiffener: $\frac{385}{3} = 128.3^k/\text{rib} \div 30.0 = 4.3\ \text{in}^2$
allow. bearing

Use 4½×1 stiff: area = 4×1×2 = 8.0 ok.

Weld Size = $\frac{128.3}{2\times(8\times2)\times12.5\times0.707} = 0.45$ Use ½"

Fixed Shoe:

Longitudinal Force = 15% LL

assume Continuous rail and the effective LF = $L/1200$

$= \frac{79}{1200} = 0.066$

LF = 243×0.15×0.066 = 2.4^k negligible

Try 28×3" at top · bearing = $\frac{385}{28\times3}$ = 4.58 ksi < 13.5

Max dim. at top of Masonry ℞:

Effect. L: $L_B - L_T < 2H$ $L_B = 2\times15 + 28 = 58"$

Effect. W: $W_B - W_T < 2H$ $W_B = 2\times15 + 3 = 33"$

Masonry ℞: Use 4" thick, L = 44", W = 16"

bearing = $\frac{385}{44\times16} = 0.547$ ksi

Anchor bolts: Max horizontal force = 21^k/shoe (See exp. shoe)

Use 4-⅞"φ H.S. bolt for Shoe to Girder connection
4-1½φ Anchor bolts for Shoe to Abut. "

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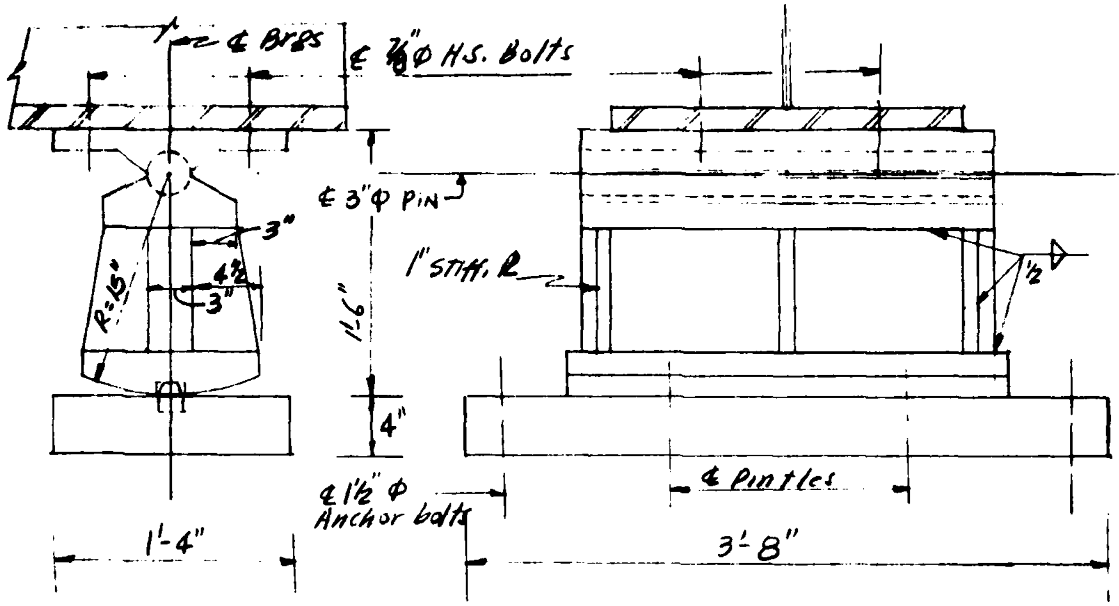
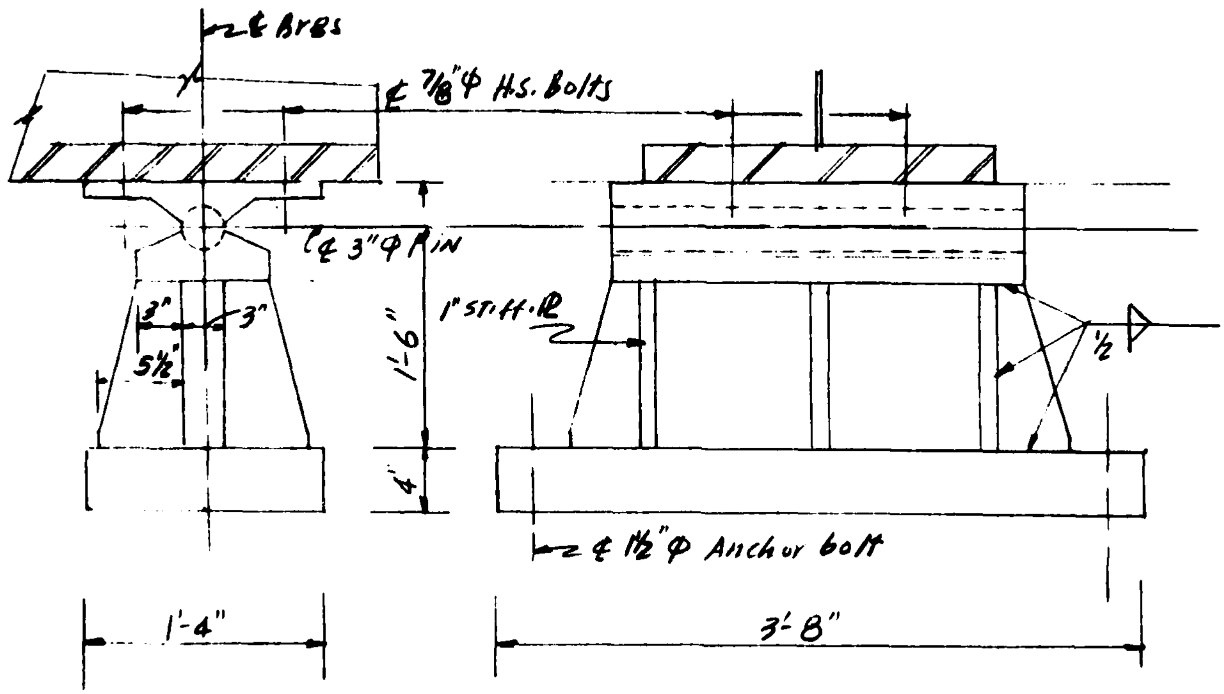


Expansion Shoe
scale 1"=1'-0"



Fixed Shoe
scale 1"=1'-0"

D2-31

6318

Relocated B&O Railroad Bridge - Mainline - Abut. Design

Design Criteria : AREA

Concrete - f'_c = 3,000 psi , n = 10

Reinf. - f_s = 40,000 psi , f_s = 20,000 psi

Fdn on Rock - Allow Brg. Pressure = 5 tons/S.F. (min w/o tests)

Resultant within middle half (p. 8-5-4)

F.S. against Sliding = 1.5 , f = 0.60 (min w/o test)

* Concrete on sound rock with rough surface (p. 8-5-5) *

Backfill : Use Type I Granular Backfill (p. 8-5-2)

Unit Wt. = 105 lbs/cu. ft. (p. 8-5-4)

ϕ = 30° (do)

$$K_a = \frac{1-\sin\phi}{1+\sin\phi} = \frac{1-.5}{1+.5} = .333$$

Equiv. Fluid Pressure = .105 × .333 = .035 K/'/'

Surcharge : (p. 8-5-3)

For E72 Loading

$$\text{Equiv. Ht. of Fill} = \frac{72^K}{5 \times 14 \times .105} = 9.8'$$

Use Semi-Gravity Wall :

Width of Stem at top of Ftg. = ¼ Ht (8-5-8)

Superstructure Reactions : See Gdr Design

Width of Abut. = 28' (±)

DL = 70^K/28' = 2.50 K/'

$$LL = \frac{486^K}{28} \times \frac{72}{80} = \underline{15.62}\ ^{K/'} \quad \text{(without impact)}$$

18.12 K/'

Longit. Force :

For continuous rail :

$$LF = 15\% \times 15.62 \times \frac{78'}{1200} = .15\ ^{K/'} \quad (p.\ 8\text{-}2\text{-}5)$$

Ignore

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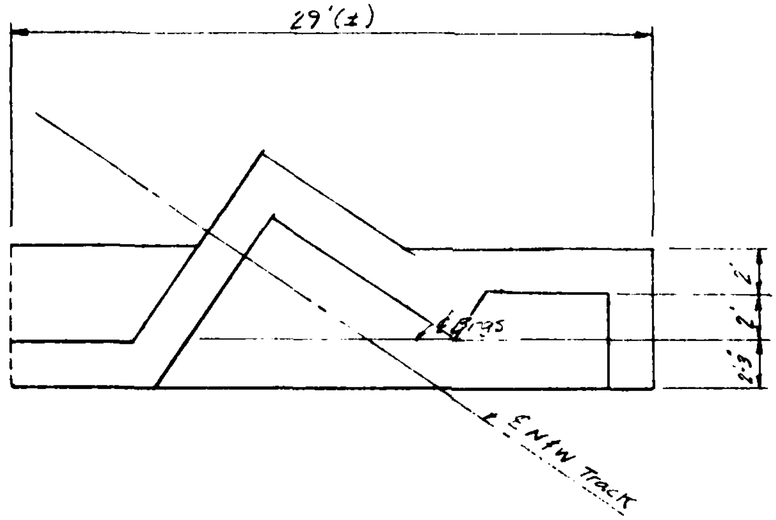
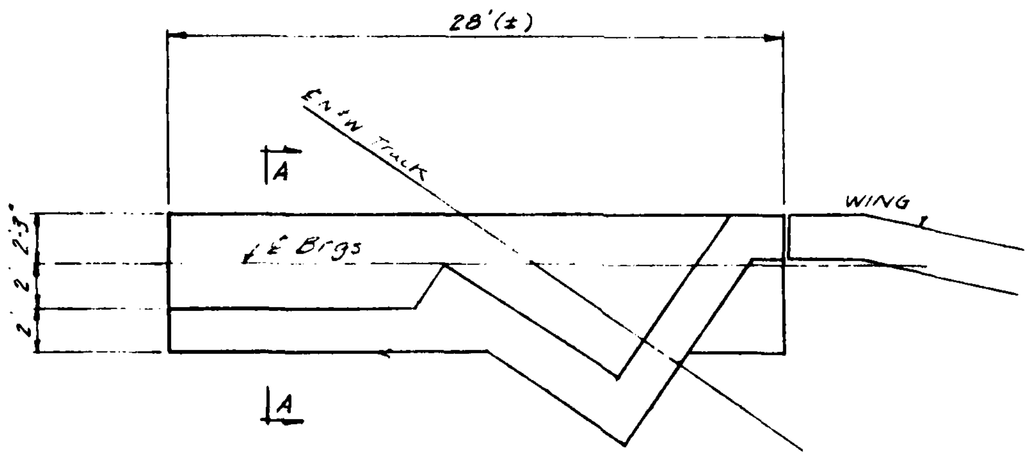
SUBJECT Big Creek Flood Control Project - Cleveland Ohio FILE NO.
SHEET NO. OF SHEETS
FOR U.S. Army Engr Dist - Buffalo - Corps of Engr.
COMPUTED BY RSM DATE 12-15-78 CHECKED BY JRS DATE 12-21-78

Abut Design (cont'd)



PLAN - ABUT. NO. 1



PLAN - ABUT. NO. 2

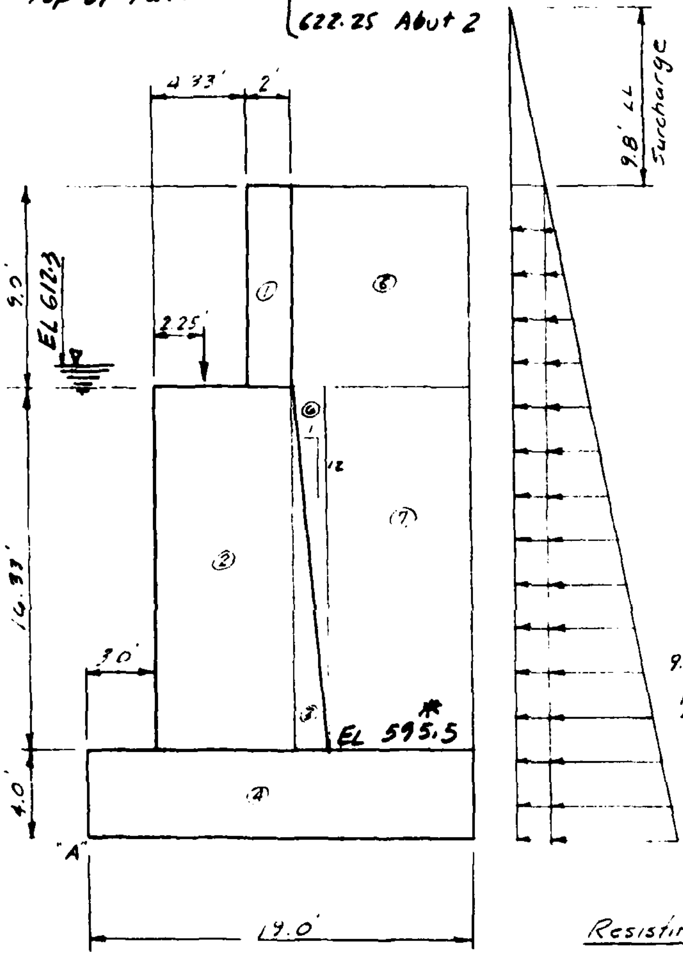
Note: Design abutment section at "A-A" for all loads including LL Surcharge. (Conservative)

D2-33

6318

Abut. Design

Top of rail EL = { 621.5 Abut 1 / 622.25 Abut 2 }



SECTION A-A

* bot. of Channel
Bot. of footing shall be located below frost line

Backwall Ht.:

Rail & Tie	= 1-5"
Gdr.	= 5-9"
Shoe	= 1-10"
	9-0"

Abut. Ht. = 29.33

Stem Width = $^{25.33}/_4$ = 6.33'

Use 1:12 Batter

Stem Width = 6.33 + $^{16.33}/_{12}$
= 7.69' > 6.33'

Earth Pressure:

9.8 × .035 × 29.33 = 10.06 × 14.66 = 147.5

½ × .035 × 29.33^2 = 15.05 × 9.78 = 147.2

H = 25.11ᴷ M_{OT} = 294.7ᴷ'

Resisting Moment about "A"

①	2.0 × 9.0 × .15	= 2.70	× 8.33	= 22.5
②	6.33 × 16.33 × .15	= 15.51	× 6.17	= 95.7
③	½ × 1.36 × 16.33 × .15	= 1.67	× 9.78	= 16.3
④	19.0 × 4.0 × .15	= 11.40	× 9.5	= 108.3
⑤	9.67 × 9.0 × .105	= 9.14	× 14.17	= 129.5
⑥	½ × 1.36 × 16.33 × .105	= 1.16	× 10.24	= 11.9
⑦	8.31 × 16.33 × .105	= 14.25	× 14.85	= 211.6
		55.83		595.8
DL React.		= 2.50	× 5.25	= 13.1
		58.33		608.9
LL React.		= 15.62	× 5.25	= 82.0

V = 73.95ᴷ M_R = 690.9ᴷ'

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SUBJECT [illegible] Flood Control FILE NO.
[illegible] Cleveland [illegible] SHEET NO. ___ OF ___ SHEETS
FOR [illegible] Engr. Dist. - Buffalo - Corps of Engr.
COMPUTED BY RSM DATE 12-18-78 CHECKED BY JRS DATE 12-26-78

[illegible] (cont'd)

[illegible] Design

[illegible] + Surcharge

Resultant at $(690.9 - 274.7)/73.95 = 5.35' > \frac{B}{4} = 4.75'$ (OK)

$e = \frac{B}{2} - 5.35 = 4.15'$

$q_{max} = \frac{2V}{3(\frac{B}{2} - e)} = \frac{2 \times 73.95}{3(9.5 - 4.15)} = 9.43\ ^{K}/_{SF} < 10$ (OK)

F.S. Sliding $= \frac{73.95 \times 0.60}{25.11} = 1.77 > 1.5$ (OK)

CL + Surcharge

Resultant at $(608.9 - 274.7)/58.33 = 5.39' > \frac{B}{4} = 4.75'$

$e = 9.5 - 5.39 = 4.11'$

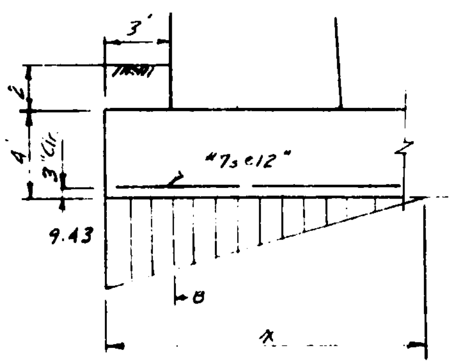
$q_{max} = \frac{2 \times 58.33}{3(9.5 - 4.11)} = 7.22\ ^{K}/_{SF}$

F.S. Sliding $= 58.33 \times 0.6 / 25.11 = 1.39$ (Call OK)

Pour footing against rock (ok as a key)

Bearing pressure (toe) $= 25.11 \div 4 = 6.3\ ^{K}/_{SF}$ (Neglect friction).

Toe Design



$x = 3(\frac{B}{2} - e)$

$= 3(9.5 - 4.15) = 16.05'$

$q_B = 9.43 \times \frac{13.05}{16.05} = 7.68\ ^{K}/_{SF}$

	V_B	M_B
$-4 \times 3 \times .15$	$= (-)1.80$	$\times 1.5 = (-)\ 2.70$
7.68×3	$= 23.04$	$\times 1.5 = 34.56$
$\frac{1}{2} \times 1.75 \times 3$	$= 2.63$	$\times 2.0 = 5.25$
	23.87^{K}	$37.11^{K'}$

Req'd $A_s = \frac{37.11}{1.44 \times 44.5} = 0.58\ ^{□}/_{'}$ Try #7s @ 12"

$A_s = 0.60$

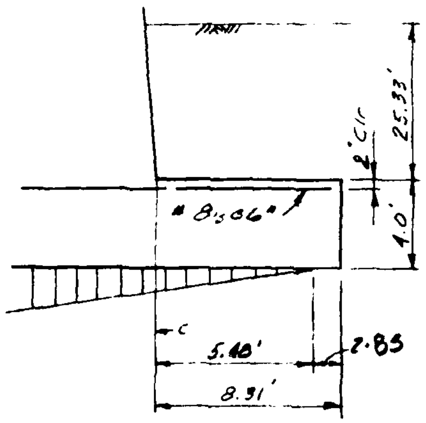
Req'd $\Sigma_o = \frac{23.87}{300 \times \frac{7}{8} \times 44.5} = 2.04\ ''/_{'}$ OK $\Sigma_o = 2.80$

$\mu = 300$ psi

: d" from face (p. 8-2-12 & 8-2-10)

$d > 3.0'$

Abut. Design (cont'd)
Heel Design



For DL + Surch. Condition:

$x = 3(9.5 - 4.11) = 16.17$

$q_c = 7.22 \times \frac{5.48}{16.17} = 2.45$ K/S.F.

	V_c		M_c
$-\frac{1}{2} \times 5.48 \times 2.45$	$= -6.70$	$\times 1.83$	$= (-)12.2$
$8.31 \times 25.33 \times .105$	$= 22.10$	$\times 4.16$	$= 91.9$
$8.31 \times 4.0 \times .15$	$= 5.00$	$\times 4.16$	$= 20.7$
	20.40^K		$100.4^{K'}$

$M_{RESIST} = 226 \times 1.94 = 438^{k\text{-}l}$ ok

Req'd $A_s = \frac{100.4}{1.44 \times 45.5} = 1.53^{\square''}$

$\Sigma_o = \frac{20.40}{.186 \times \frac{7}{8} \times 45.5} = 2.75''$ (OK)

Try # : 6"
$A_s = 1.58^{\square''}$
$\Sigma_o = 3''$
$u = 186$ psi (top bar)

v_c @ "d" from face: $q_d = 7.22 \times 1.6^8/_{16.17} = 0.75$ K/S.F

$V = 20.40 - 3.79(25.33 \times .105 + 4.0 \times .15) + 3.79 \times \frac{1}{2}(.75 + 2.45)$

$= 20.40 - 12.35 + 6.06 = 14.11^K$

$v_c = \frac{14.11}{12 \times 45.5} = 0.026$ Ksi

Allow $v_c = 1.1\sqrt{f'_c}$ (p. 8-2-10)

$= 0.060$ Ksi (OK)

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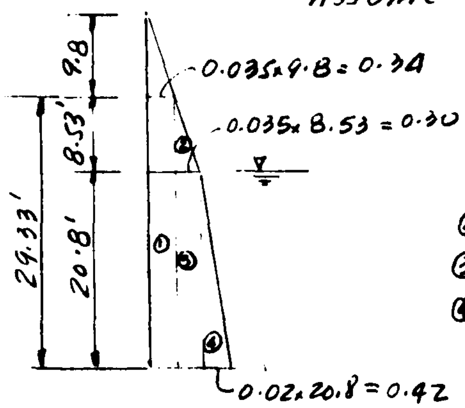
Abutment stability (cont.)

DL + LL Surcharge + Buoyancy :

Assume $\gamma' = 60$ #/CF and $P_a = 0.06 \times 0.333 = 0.02$ K/F



Earth pressure :

① = 0.34 × 29.33	=	9.97 × 14.67 =	146.3
② = 0.3 × 8.53 × 0.5	=	1.28 × 23.64 =	30.2
③ = 0.3 × 20.8	=	6.24 × 10.4 =	64.9
④ = 0.42 × 20.8 × 0.5	=	4.37 × 6.93 =	30.3
		21.86	271.7

Resisting moment : About A : See Section A-A :

① thru ⑤ :	=	40.42	=	372.3
⑥ : 1.16 × 0.06 ÷ 0.105	=	0.66 × 10.24	=	6.8
⑦ : 14.25 × 0.06 ÷ 0.105	=	8.14 × 14.85	=	120.9
DL	=	2.50 × 5.25	=	13.1
LL Surcharge = 72 × 9.67/14 × 5	=	9.95 × 14.17 (*)	=	140.9
② · 15.5 × 62.4/150	=	−6.45 × 6.17	=	−39.8
③ · 1.67 × 62.4/150	=	−0.70 × 9.78	=	−6.8
④ 11.40 × 62.4/150	=	−4.74 × 9.50	=	−45.1
		49.78		562.3

$* \frac{9.67}{2} + 9.33 = 14.17$

Resultant at $(562.3 - 271.7) \div 49.78 = 5.84 > B/4$

F.S. (sliding) = $49.78 \times 0.6 \div 21.86 = 1.36 < 1.5$

Note. Pour footing against rock and use as a key to resist horizontal loads.

DL + LL + Surcharge + Buoyancy

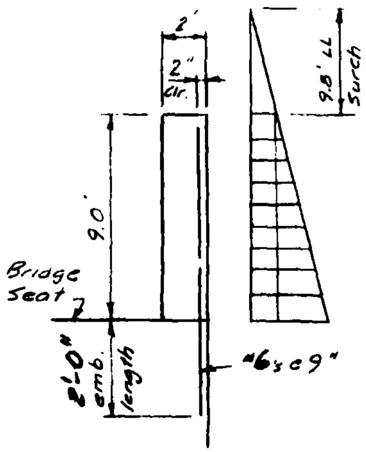
F.S (sliding) = $(49.78 + 15.62) \times 0.6 \div 21.86 = 1.80$

Resultant at : $(562.3 + 82 - 271.7) \div (49.78 + 15.62) = 5.70 > B/4$

8815

Abutment Design (cont'd)

Backwall



Earth Pressure:

$9.8 \times .035 \times 9 = 3.09 \times 4.5 = 13.89$

$\frac{1}{2} \times .035 \times 9^2 = 1.42 \times 3.0 = 4.25$

$H = 4.51^k \quad M = 18.14^{k'}$

Design for pure bending:

$$\text{Req'd } A_s = \frac{18.14}{1.49 \times 21.5} = .59^{\square''}$$

Use #6's @ 9" $\quad A_s = 0.59^{\square''}$

$$u = \frac{4.8 \times \sqrt{3000}}{0.75} = 0.35 \qquad \Sigma_o = 3.1$$

$$\text{Emb. Length} = \frac{20 \times .59}{3.1 \times .350} = 10.9''_{min}$$

Use Eff Depth = 1'-10" (p. D-2-14)

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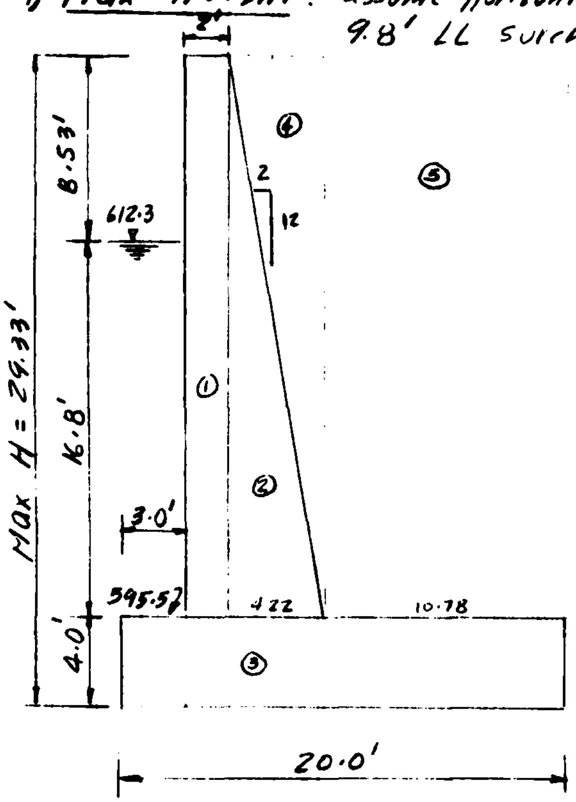
GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

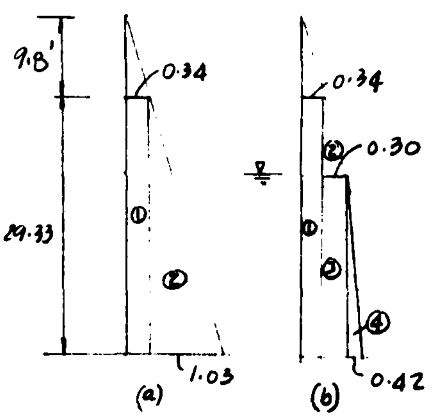
SUBJECT: Big Crock R.R. Bridge — Main Line   FILE NO. ____
SHEET NO. ____ OF ____ SHEETS
FOR ____
COMPUTED BY JRS DATE 12-28-78 CHECKED BY RSM DATE 1-10-79

Wing Wall Design:

1) Max Height: assume Horizontal fill behind wall ($\beta = 0$) but use 9.8' LL surcharge.



Min Width at top of footing
$= 25.33/4 = 6.33$
Use 2:12 batter



a) DL + LL surcharge:

Earth pressure:

① $0.34 \times 29.33 = 9.97 \times 14.67 = 146.3$

② $1.03 \times 29.33 \times 0.5 = 15.10 \times 9.78 = 147.7$

$\quad 25.07 \qquad 294.0$

F.S. (sliding)
$= 61.9 \times 0.6 \div 25.07 = 1.49 \approx 1.5$

Resisting moment

① $2.0 \times 25.33 \times 0.15 = 7.60 \times 4.0 = 30.4$

② $4.22 \times 25.33 \times 0.5 \times 0.15 = 8.02 \times 6.41 = 51.4$

③ $4.0 \times 20.0 \times 0.15 = 12.0 \times 10.0 = 120.0$

④ $4.22 \times 25.33 \times 0.5 \times 0.105 = 5.61 \times 7.81 = 43.8$

⑤ $10.78 \times 25.33 \times 0.105 = 28.67 \times 14.61 = 418.9$

$\quad 61.90(*) \qquad 664.5$

Resultant at:
$(664.5 - 294.0) \div 61.9 = 5.92$
$> B/4$
$e_{cc} = 10.0 - 5.92 = 4.08$

* Without Wt of LL Surcharge (Conservative for stability)

$P_{max} = 2 \times 61.9 \div [3 \times (\frac{20}{2} - 4.08)] = 7.0\ ^{k}/_{SF}$

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GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Big creek R.R. Bridge FILE NO.
Main Line SHEET NO. OF SHEETS
FOR
COMPUTED BY JRS DATE 12-29-78 CHECKED BY RSM DATE 1-10-79

Wing wall (Cont.)

b) DL + LL Surcharge + Buoyancy

Earth pressure:

① = 0.34 × 29.33	=	9.97	× 14.68	=	146.4
② = 0.30 × 8.53 × 0.5	=	1.28	× 23.64	=	30.2
③ = 0.30 × 20.8	=	6.24	× 10.4	=	64.9
④ = 0.42 × 20.8 × 0.5	=	4.37	× 6.93	=	30.3
		21.86			271.8

Resisting moment:

① thru ⑨ =	=	27.62		=	201.8
$-27.62 \times \frac{62.4}{150}$	=	-11.49	$201.8 \times \frac{62.4}{150}$	=	-83.9
8.53 × 2.0 × 0.0624	=	1.06	× 4.0	=	4.3
1.42 × 8.53 × 0.5 × 0.0624	=	0.38	× 5.47	=	2.1
1.42 × 8.53 × 0.5 × 0.105	=	0.64	× 5.95	=	3.8
2.8 × 8.53 × 0.105	=	2.51	× 7.82	=	19.6
2.8 × 16.8 × 0.5 × 0.06	=	1.41	× 8.29	=	11.7
10.78 × 8.53 × 0.105	=	9.66	× 14.61	=	141.1
10.78 × 16.8 × 0.06	=	10.87	× 14.61	=	158.8
Wt LL surcharge = $\frac{72 \times 15}{14 \times 5}$	=	15.43	× 12.5*	=	192.9
		58.09			652.2

$* = \frac{15.0}{2} + 2.0 + 3.0 = 12.5$

F.S. (Sliding)
$= 58.09 \times 0.6 \div 21.86$
$= 1.59$

Resultant at $(652.2 - 271.8) \div 58.09 = 6.54 < B/4$

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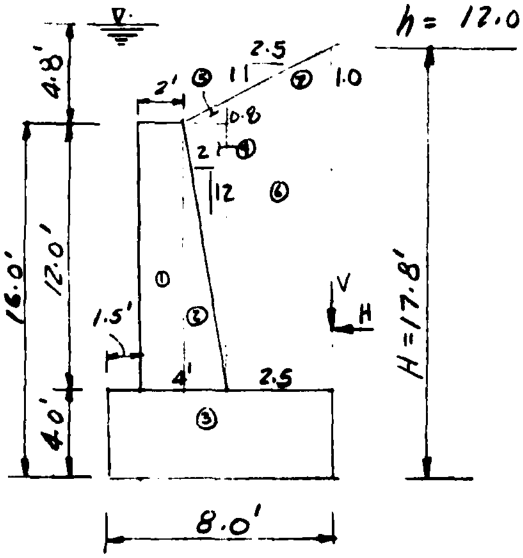
GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT: Big Creek R.R. Bridge — Main Line
FILE NO. ____ SHEET NO. ____ OF ____ SHEETS
FOR ____
COMPUTED BY: JKS DATE: 12-29-78 CHECKED BY: KSM DATE: 1-3-79

Wing Wall (cont.)

2) Min Height:

Top of Wing Wall El = 607.5
Top of footing El = 595.5
h = 12.0'



$V = \frac{1}{2} K_v H^2$

$H = \frac{1}{2} K_h H^2$

Use 2.5:1 slope

Back fill material type 1

From AREA 8-5-17:

$K_V = 0.012^{k}/SF$

$K_H = 0.032^{k}/SF$

$V = \frac{1}{2} \times 0.012 \times 17.8^2 = 1.90$

$H = \frac{1}{2} \times 0.032 \times 17.8^2 = 5.07$

$M_H = 5.07 \times 5.93 = 30.1$

Resisting Moment:

① : 2.0×12.0×0.15	= 3.60	×2.5	=	9.0
② : 2.0×12.0×0.5×0.15	= 1.80	×4.17	=	7.5
③ : 8.0×4.0×0.15	= 4.80	×4.0	=	19.2
④ : 2.0×12.0×0.5×0.105	= 1.26	×4.83	=	6.1
⑤ : 0.8×2.0×0.5×0.105	= 0.08	×4.83	=	0.4
⑥ : 2.5×12.8×0.105	= 3.36	×6.75	=	22.7
⑦ : 2.5×1.0×0.5×0.105	= 0.13	×7.17	=	0.9
V	= 1.90	×8.0	=	15.2
	16.93			81.0

F.S. (sliding)

$= \frac{16.93 \times 0.6}{5.07} = 2.0$

Resultant at:

$(81.0 - 30.1) \div 16.93$

$= 3.0 > B/4$

$e = \frac{B}{2} - 3 = 1.0$

Buoyancy:

	10.20	35.7
① thru ③:	$10.2 \times 62.4/150 = -4.24$	$35.7 \times \frac{62.4}{150} = -14.9$
④ thru ⑦:	$4.83 \times 0.06/0.105 = 2.76$	= 17.2
V	$1.90 \times \frac{0.06}{0.105} = 1.09$	= 8.7
	9.81	46.7

$P_{max} = \frac{16.93}{8}\left(1 + \frac{6 \times 1.0}{8}\right)$

$= 3.7^{k}/SF$

$\Sigma H = 5.07 \times 0.06/0.105 = 2.90$ M = 17.2

F.S (sliding) = 2.02

Resultant at: $(46.7 - 17.2)/9.81 = 3.0 > B/4$

02-41

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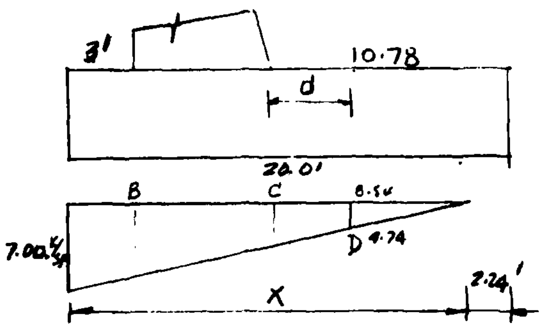
(Wing Wall Cont.)
(Max h)

Toe design: Neglect foot. cover.



$X = 3(\frac{20}{3} - 4.08) = 17.76$

$q_B = 7.00 \times \frac{14.76}{17.76} = 5.82$

			M_B
$V_B = -3 \times 0.15 \times 4$	$= -1.8$	$\times 1.5$	$= -2.7$
5.82×3.0	$= 17.5$	$\times 1.5$	$= 26.2$
$1.18 \times 3.0 \times 0.5$	$= 1.8$	$\times 2.0$	$= 3.6$
	17.5		27.1

v @ "d" from face = 0

$A_s = 27.1 \div (1.44 \times 44.5) = 0.42\ in^2/'$

$\Sigma_0 = \frac{17.5}{0.35 \times 0.875 \times 44.5} = 1.28\ in/'$

Use #6 @ 12"(+) $\begin{cases} A_s = 0.44 \\ \Sigma_0 = 2.4 \end{cases}$

Heel design: $q_C = 7.00 \times 8.54/17.76 = 3.37$

(neglect Wt of Surcharge)

			M_C
$V_C = -3.37 \times 8.54 \times 0.5$	$= -14.4$	$\times 2.85$	$= -41.0$
$25.33 \times 0.105 \times 10.78$	$= 28.7$	$\times 5.39$	$= 154.5$
$4.0 \times 0.15 \times 10.78$	$= 6.5$	$\times 5.39$	$= 34.9$
	20.8		148.4

$A_s = 148.4 \div (1.44 \times 45.5) = 2.30\ in^2/'$

$\Sigma_0 = \frac{20.8}{0.146 \times 0.875 \times 45.5} = 3.60\ in/'$

Use #10 @ 6"(+) $\begin{cases} A_s = 2.54 \\ \Sigma_0 = 8.0 \end{cases}$

Shear @ "d" from C:

$q_D = 7.00 \times 4.74/17.76 = 1.87$

$V_D = -1.87 \times 4.74 \times 0.5 + (25.33 \times 0.105 + 4.0 \times 0.15) \times 6.99 = 18.6$

$v = 18.6 \div (12 \times 45.5) = 0.034\ k/in^2$

allow $v_c = 0.06$

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SUBJECT: Big Creek R.R. Bridge — Main Line FILE NO. ____
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FOR ____
COMPUTED BY: JKS DATE: 1-2-79 CHECKED BY: RSM DATE: 1-12-79

Wing wall (cont.)

Check reinforcement @ 32' from Exp. Joint: ($\frac{1}{3}$ pt of tapered section)

assume Wing length = 66'

Total Wing height from 29.33' to 16'

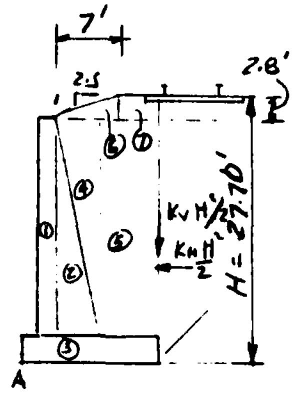
Footing Width from 20' to 8'

Wing Section @ 32':

$h = 4.0 + 12.0 + (25.33 - 12.0) \times \frac{36}{54} = 24.9'$

$Toe = 1.5 + (3.0 - 1.5) \times 36/54 = 2.50'$

$Footing\ Width = 8.0 + (20.0 - 8.0) \times 36/54 = 16'$



Resisting Moments. Moments about "A"

① :	$2.0 \times 20.9 \times 0.15$	= 6.27	× 3.50 =	21.9
② :	$20.9 \times \frac{2}{12} \times 20.9 \times 0.15 \times 0.5$	= 5.46	× 5.66 =	30.9
③ :	$4.0 \times 16.0 \times 0.15$	= 9.60	× 8.0 =	76.8
④ :	$3.48 \times 20.9 \times 0.105 \times 0.5$	= 3.82	× 6.82 =	26.0
⑤ :	$8.02 \times 20.9 \times 0.105$	: 17.60	× 12.01 =	211.2
		42.75		366.8

Earth pressure : distance from footing to edge of tie is less than height of wall.

assume full live load surcharge $h' = 9.8'$

$H = 27.7$

For 2.5:1 slope and $\frac{H_1}{H} = 0$ $K_V = 0$ and $K_H = 0.032$

$\frac{1}{2} K_H H^2 = 0.5 \times 0.032 \times \overline{27.7}^2 = 12.27$ $M_A: 12.27 \times \frac{27.7}{3} = 113.4$

$Surcharge = 9.8 \times 0.035 \times 24.9 = 8.50$ $M_A\ 8.5 \times \frac{24.9}{2} = 105.8$

⑥ :	$\frac{7.0}{2.5} \times 7.0 \times 0.5 \times 0.105$	= 1.03	× 9.17 =	9.4
⑦ :	$2.8 \times 4.50 \times 0.105$	= 1.32	× 13.75 =	18.2
	Σ ⑥+⑦	= 2.35		27.6

F.S. (sliding) = $(42.75 + 2.35) \times 0.6 \div (12.27 + 8.5) = 1.30$

Resultant at : $(366.8 + 27.6 - 113.4 - 105.8) \div 45.1 = 3.88$

Max bearing pressure $= \frac{45.1 \times 2}{(3 \times 3.88)} = 7.74\ ^k/SF$

Toe design. $X = 3 \times 3.88 = 11.64$

$q_B = 7.74 \times \frac{9.14}{11.64} = 6.08$

				M_B
V_B =	$-4.0 \times 0.15 \times 2.50$	= −1.5	× 1.25	= −1.9
	6.08×2.5	= 15.2	× 1.25	= 19.0
	$1.66 \times 2.5 \times 0.5$	= 2.08	× 1.67	= 3.5
		15.78		20.6

DZ-43

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Section @ 32' (cont.)

$A_s = 20.6 \div (1.44 \times 44.5) = 0.32$

$\Sigma_o = 15.78 \div (0.35 \times 0.875 \times 44.5) = 1.16$

Use #6 @ 12" (t) $\begin{cases} A_s = 0.44 \\ \Sigma_o = 2.4 \end{cases}$

Heel design:

$q_c = 7.74 \times \frac{3.66}{11.6} = 2.43$

$V_c = -2.43 \times 3.66$	$= -4.45$	$\times 1.22 =$	5.43
$4 \times 8.02 \times 0.15$	$= 4.81$	$\times 4.0 =$	19.2
$23.7 \times 8.02 \times 0.105$	$= 19.96$	$\times 4.0 =$	79.8
	20.32		93.57

$A_s = 93.57 \div (1.44 \times 45.5) = 1.43$

$\Sigma_o = 20.32 \div (0.132 \times 0.875 \times 45.5) = 3.8$

Use #11 @ 12" (t)

$A_s = 1.56$

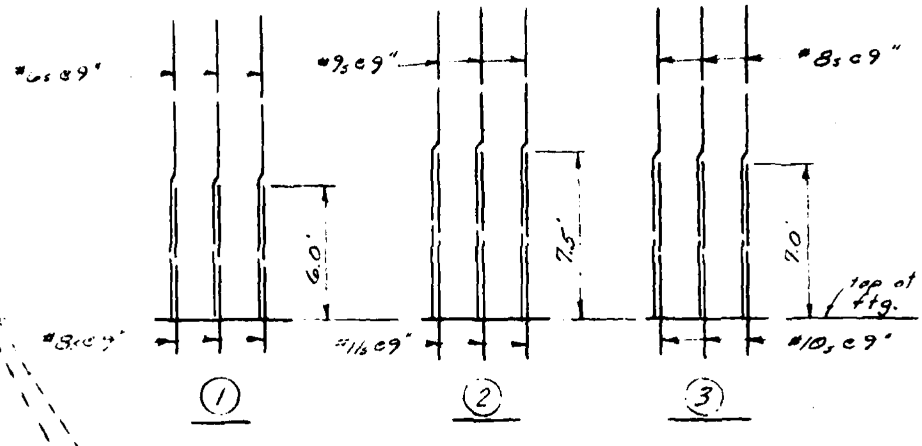
$\Sigma_o = 4.4$

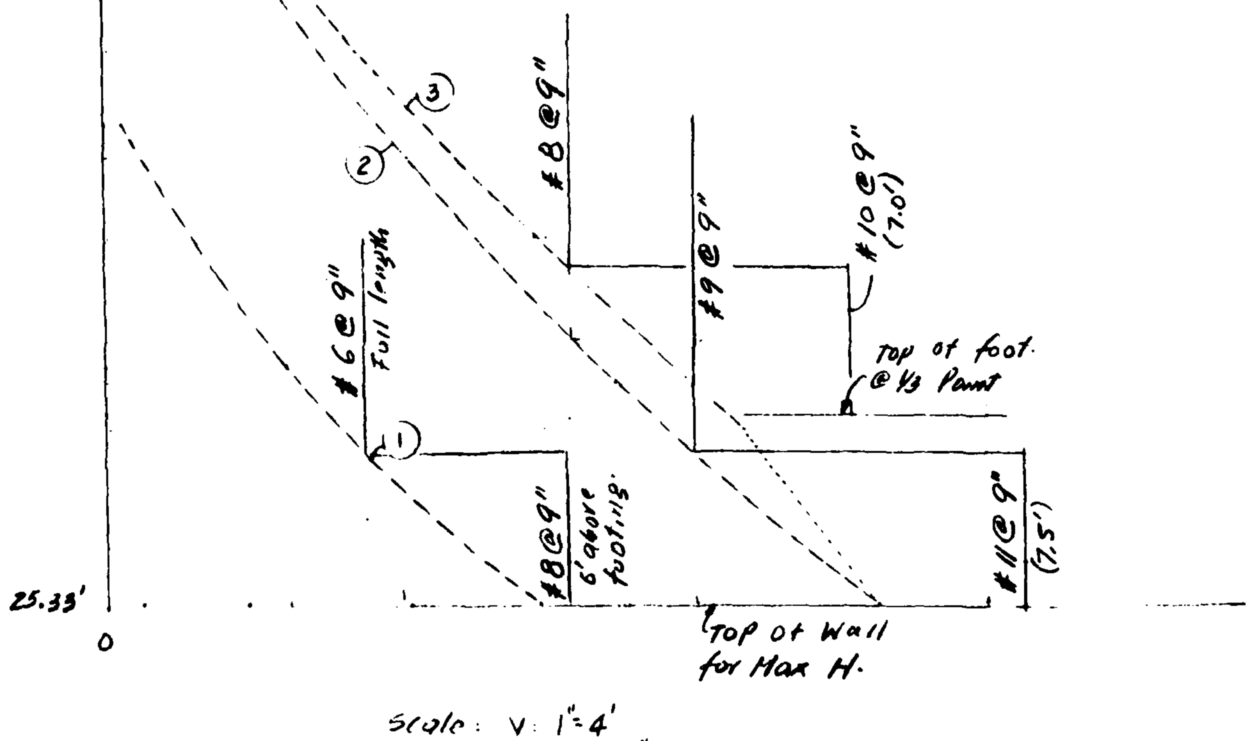
Shrinkage and Temperature steel will be detailed in accordance with AREA Specs.

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Big Creek R.R. Bridge FILE NO.
Main Line SHEET NO. OF SHEETS
FOR
COMPUTED BY VRS DATE 1-3-79 CHECKED BY REM DATE 1-12-79

Abutment (cont.)
Stem Design: see program RWM





Scale: V: 1" = 4'
H: 1" = 0.4 ..

(1): Abutment
(2): Wing with LL surcharge only but near wall
(3): Wing with LL surcharge and inclined DL surcharge. D2-45

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```
READY edit rwm (el)
EDIT  run

RETAINING WALL(0), OR ABUTMENT(1)
?     1
WT. OF CONC. & BACKFILL(KCF)  EQUIV. FLUID PRES. (KSF/FT. DEPTH)
?     .15 .105 .035
PAVEMENT THICKNESS(FT)
?     6
FOOTING WIDTH,DEPTH & TOE LENGTH (FT)
?     19 4 3
DIST. OF 1ST ROW OF PILES FROM THE TOE(FT)
?     1.5
MAX. DESIGN PILE LOAD(KIPS)
?     150
CONC. ALLOW. FC & SHEAR STRESS (KSI) OF FOOTING
?     1.35 .06
ALLOW. FS (KSI) & ELAS. MODULUS RATIO OF FOOTING
?     20 10
CONC. COVER TO C.L. OF BOT. & TOP STEEL - INCHES
?     3.5 2.5
WALL HEIGHT(FT)
?     25.33
CONC. ALLOW. FC & SHEAR STRESS (KSI) OF STEM
?     1.35 .06
ALLOW. FS (KSI) & ELAS. MODULUS RATIO OF STEM
?     20 10
CONC.COVER TO C. L. OF STEM STEEL - INCHES
?     2.5
BEAM SEAT HEIGHT & WIDTH(FT)
?     9 4.33
BACKWALL HEIGHT & WIDTH(FT)
?     9 2
BACKWALL BATTER HEIGHT & WIDTH(FT)
?     0 0
```

ABUTMENT - Mainline

Use for Stem Steel Only

ChKd: RSM (1-12-79)

NOTE:

Results from Retaining Wall-Abutment Design Program. Only wall design portion of program was needed. However, total program had to be run. Computer program output not applicable to stem design is crossed out.

Writeup for this program at end of this subappendix.

```
ABUTMENT BATTER(N/12)
?      1
DIST. WALL F.F. TO BRG. C.L.(FT)
?      2.25
DEAD LOAD & LIVE LOAD REACTIONS(K/FT)
?      2.5 15.62
ADDITIONAL VERT. & HORIZ. FORCES(K/FT) APPL. AT C.L. BRGS.
?      0 0
GROUP FACTOR
?      1
LIVE LOAD SURCHARGE(FT)
?      9.8
```

ABUTMENT
Use for stem design only
Chkd : RSM (1-12-79

```
MOM & FORCES CAUSED BY SUBSTRUC.EARTH PRESS & LL SURCH
     VERT FORCE(K/FT)     55.824     RESISTING MOMENT(K-FT/FT)    511.843
     HORI FORCE(K/FT)     25.115     OVERTURN  MOMENT(K-FT/FT)    294.714


# OF PILE ROWS(MAX. 6)
?      3
DIST. FROM 1ST ROW(FT) & BATTER(N/12) OF EACH ROW
?      0 3 3 3 16 0
EACH ROW PILE SPACING(FT)
?      3 3 6
TOTAL PILE AREA(PILE/FT)        0.833
  ROW          VERT. LOAD         TOTAL LOAD        HORI(BATT)        HORI(BEND)
    1             94.733             97.649            23.683            11.600      KIPS/PILE
    2             90.642             93.432            22.661            11.600      KIPS/PILE
    3             72.914             72.914             0.000            11.600      KIPS/PILE
      (NOTE: ALL PILE LOADS INCLUDE LIVE LOAD SURCHARGE)
ANOTHER TRIAL? YES=1.NO=0
?      0
CHANGE FOOTING? YES=1.NO=0
?      0
```

ABUTMENT (Cont.)

Chk'd: RSM (1-12-79)

FOOTING DESIGN

	REQD. DEPTH (IN)	ACTUAL DEPTH (IN)	REQD. STEEL (SQ. IN/FT)	SHEAR STRESS (KSI)
HEEL	20.740	45.500	0.454	0.027
TOE	13.773	44.500	0.696	0.001

THE FOOTING DESIGN IS O.K.
CHANGE FOOTING? YES=1,NO=0
? 0

STEM DESIGN

HEIGHT (FEET)	COMP STEEL REQD?	ACTUAL DEPTH (INCHES)	REQD AS (SQ IN/FT)	SHEAR (KSI)
9.000	NO	21.500	0.528	0.017
9.000	NO	73.460	0.000	0.005
14.443	NO	78.903	0.033	0.009
19.887	NO	84.347	0.419	0.014
25.330	NO	89.790	0.984	0.018

NEW DESIGN? YES=1,NO=0
? 0
END OF PROGRAM
EDIT end

Embedment length for #8 bar $= \frac{0.79 \times 20.0}{3.142 \times 0.263} = 19''$

AD-A102 433 CORPS OF ENGINEERS BUFFALO NY BUFFALO DISTRICT F/6 13/2
BIG CREEK FLOOD CONTROL PROJECT, CLEVELAND, OHIO. PHASE II. GEN--ETC(U)
AUG 79

UNCLASSIFIED NL

3 OF 4
AD A
102433

```
      edit rwm ipli
EDIT  run

RETAINING WALL(0), OR ABUTMENT(1)
?     0
WT. OF CONC. & BACKFILL(KCF)  EQUIV. FLUID PRES. (KSF/FT. DEPTH)
?     .15 .105 .035
PAVEMENT THICKNESS(FT)
?     0
FOOTING WIDTH,DEPTH & TOE LENGTH (FT)
?     21 4 4
DIST. OF 1ST ROW OF PILES FROM THE TOE(FT)
?     1.5
MAX. DESIGN PILE LOAD(KIPS)
?     150
CONC. ALLOW. FC & SHEAR STRESS (KSI) OF FOOTING
?     1.35 .06
ALLOW. FS (KSI) & ELAS. MODULUS RATIO OF FOOTING
?     20 10
CONC. COVER TO C.L. OF BOT. & TOP STEEL - INCHES
?     3.5 2.5

WALL HEIGHT(FT)
?     25.33
CONC. ALLOW. FC & SHEAR STRESS (KSI) OF STEM
?     1.35 .06
ALLOW. FS (KSI) & ELAS. MODULUS RATIO OF STEM
?     20 10
CONC.COVER TO C. L. OF STEM STEEL - INCHES
?     2.5
PARAPET HEIGHT & WIDTH(FT)
?     0 0
STEM WIDTH(FT) & BATTER(N/12)
?     2 2
SURCHARGE SLOPE & SLOPE DIST.(FT)
?     0 0
LIVE LOAD SURCHARGE(FT)
?     9.8
```

WING (Max H.)

Use for stem design only

Chk'd: RSM (1-12-79)

```
MOM & FORCES CAUSED BY SUBSTRUC.EARTH PRESS & LL SURCH
     VERT FORCE(K/FT)    62.500     RESISTING MOMENT(K-FT/FT)   632.945
     HORI FORCE(K/FT)    25.115     OVERTURN  MOMENT(K-FT/FT)   294.714

PRESSURE= 0.035K/SF/F     PRESSURE SLOPE= 0.00

# OF PILE ROWS(MAX. 6)
?      3
DIST. FROM 1ST ROW(FT) & BATTER(N/12) OF EACH ROW
?      0 3 3 3 18 0
EACH ROW PILE SPACING(FT)
?      3 3 6
TOTAL PILE AREA(PILE/FT)         0.833
  ROW        VERT. LOAD        TOTAL LOAD        HORI(BATT)        HORI(BEND)
    1            70.145            72.303            17.536            15.805     KIPS/PILE
    2            73.179            75.431            18.295            15.805     KIPS/PILE
    3            88.351            88.351             0.000            15.805     KIPS/PILE
      (NOTE: ALL PILE LOADS INCLUDE LIVE LOAD SURCHARGE)
ANOTHER TRIAL? YES=1.NO=0
?      0
CHANGE FOOTING? YES=1.NO=0
?      0

FOOTING DESIGN
                  REQD. DEPTH   ACTUAL DEPTH    REQD. STEEL   SHEAR STRESS
                         (IN)           (IN)    (SQ. IN/FT)          (KSI)
HEEL                   28.345         45.500          0.803          0.037
 TOE                   30.686         44.500          0.836          0.041
THE FOOTING DESIGN IS      O.K.
CHANGE FOOTING? YES=1.NO=0
?      0
```

WING (MAX H.)

Chkd: RSM (1-12-79)

WING (MARH)

CHKD: RSM (-2-7?)

STEM DESIGN

HEIGHT (FEET)	COMP STEEL REQD?	ACTUAL DEPTH (INCHES)	REQD AS (SQ IN/FT)	SHEAR (KSI)
5.066	NO	31.632	0.078	0.006
10.132	NO	41.764	0.321	0.011
15.198	NO	51.896	0.690	0.015
20.264	NO	62.028	1.169	0.019
25.330	NO	72.160	1.753	0.023

```
NEW DESIGN? YES=1,NO=0
?     0
END OF PROGRAM
EDIT  end
READY
```

Embed. length for #11 bar $= \frac{1.56 \times 20.0}{4.4 \times 0.186} = 38''$

WING AT 1/3 PT of Tapered Section
Use for Stem design only

Chk'd: RSM (1-12-79)

```
      edit rwm ipli
EDIT  run

RETAINING WALL(0). OR ABUTMENT(1)
?     0
WT. OF CONC. & BACKFILL(KCF)  EQUIV. FLUID PRES. (KSF/FT. DEPTH)
?     .15 .105 .035
PAVEMENT THICKNESS(FT)
?     0

FOOTING WIDTH.DEPTH & TOE LENGTH (FT)
?     17 4 3.25
DIST. OF 1ST ROW OF PILES FROM THE TOE(FT)
?     1.5
MAX. DESIGN PILE LOAD(KIPS)
?     150
CONC. ALLOW. FC & SHEAR STRESS (KSI) OF FOOTING
?     1.35 .06
ALLOW. FS (KSI) & ELAS. MODULUS RATIO OF FOOTING
?     20 10
CONC. COVER TO C.L. OF BOT. & TOP STEEL - INCHES
?     3.5 2.5

WALL HEIGHT(FT)
?     21.3
CONC. ALLOW. FC & SHEAR STRESS (KSI) OF STEM
?     1.35 .06
ALLOW. FS (KSI) & ELAS. MODULUS RATIO OF STEM
?     20 10
CONC.COVER TO C. L. OF STEM STEEL - INCHES
?     2.5
PARAPET HEIGHT & WIDTH(FT)
?     0 0
STEM WIDTH(FT) & BATTER(N/12)
?     2 2
SURCHARGE SLOPE & SLOPE DIST.(FT)
?     .4 7
LIVE LOAD SURCHARGE(FT)
?     9.8
```

```
MOM & FORCES CAUSED BY SUBSTRUC.EARTH PRESS & LL SURCH
     VERT FORCE(K/FT)     46.513     RESISTING MOMENT(K-FT/FT)   376.081
     HORI FORCE(K/FT)     22.406     OVERTURN  MOMENT(K-FT/FT)   246.504

PRESSURE= 5.035K/SF/F     PRESSURE SLOPE= 0.00

# OF PILE ROWS(MAX. 6)
?     3
DIST. FROM 1ST ROW(FT) & BATTER(N/12) OF EACH ROW
?     0 3 3 3 14 0
EACH ROW PILE SPACING(FT)
?     3 3 6
TOTAL PILE AREA(PILE/FT)         0.833
  ROW        VERT. LOAD        TOTAL LOAD        HORI(BATT)        HORI(BEND)
    1           65.930            67.959            16.482            14.460     KIPS/PILE
    2           58.344            60.139            14.586            14.460     KIPS/PILE
    3           30.529            30.529             0.000            14.460     KIPS/PILE
      (NOTE  ALL PILE LOADS INCLUDE LIVE LOAD SURCHARGE)
ANOTHER TRIAL? YES=1,NO=0
?     0
CHANGE FOOTING? YES=1,NO=0
?     0

FOOTING DESIGN
                     REQD. DEPTH   ACTUAL DEPTH    REQD. STEEL   SHEAR STRESS
                            (IN)           (IN)    (SQ. IN/FT)          (KSI)
HEEL                      28.897         45.500          1.127          0.038
 TOE                      12.242         44.500          0.550          0.002
THE FOOTING DESIGN IS     O.K.
CHANGE FOOTING? YES=1,NO=0
?     0
```

Wing at 1/3 (Cont.)

Chkd: RSM (1-2-79)

Wing at 1/3 Pt (Cont.)

Chk'd: RSM (1-12-79)

STEM DESIGN

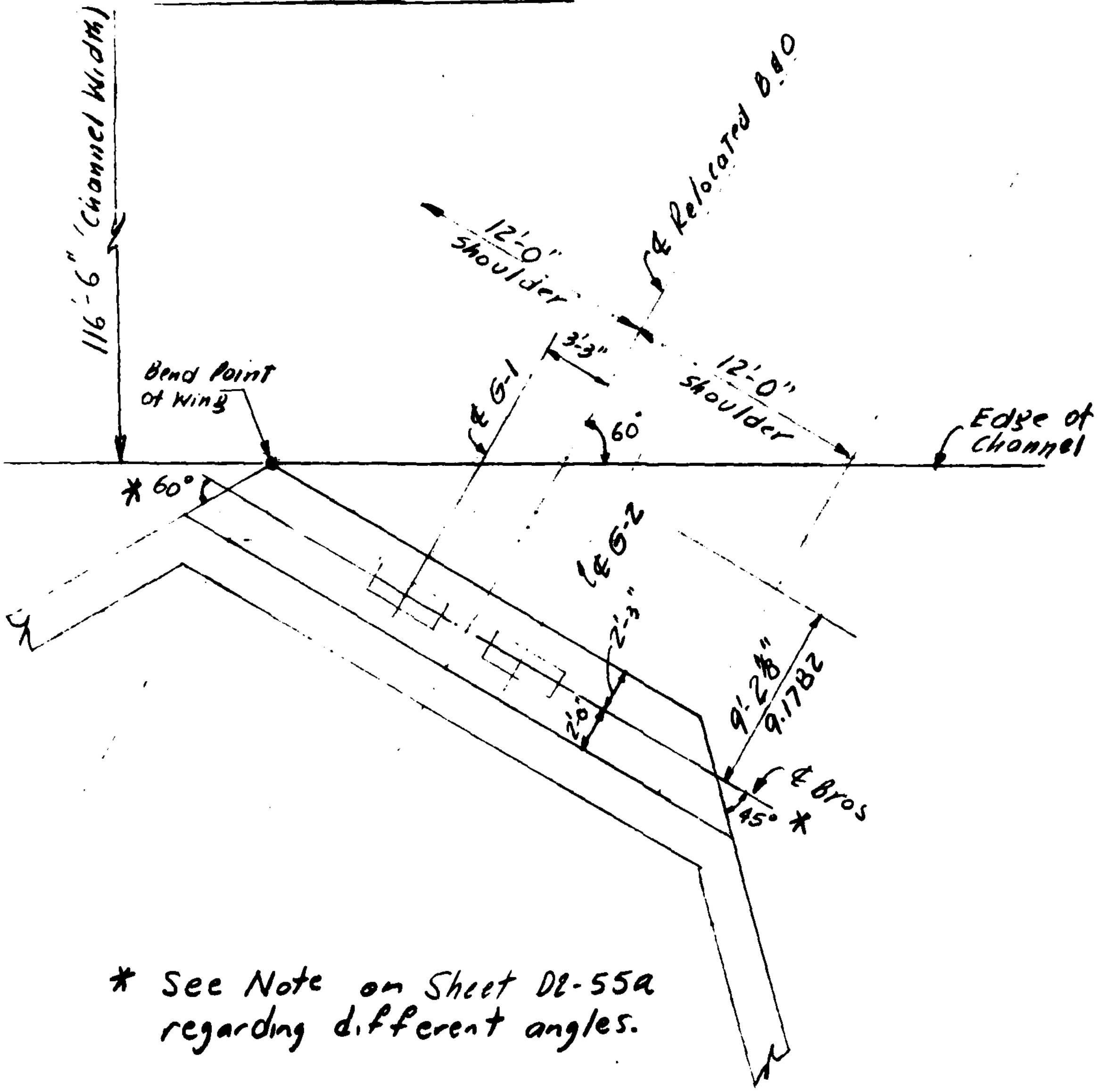
HEIGHT (FEET)	COMP STEEL REQD?	ACTUAL DEPTH (INCHES)	REQD AS (SQ IN/FT)	SHEAR (KSI)
4.260	NO	30.020	0.067	0.005
8.520	NO	38.540	0.275	0.010
12.780	NO	47.060	0.584	0.013
17.040	NO	55.580	0.978	0.017
21.300	NO	64.100	1.452	0.020

```
NEW DESIGN? YES=1,NO=0
?    0
END OF PROGRAM
EDIT  end
READY logoff
LOGGED OFF AT  10.33.21  01/03/79
#SESSION DURATION  00.32.36  CPU TIME USED   46299/300THS SEC.
```

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Big Creek R.R. Bridge
Spur Line
FILE NO.
SHEET NO. OF SHEETS
FOR
COMPUTED BY JRS DATE 1-8-79 CHECKED BY SEM DATE 1 10 79

ABUTMENT LOCATION:



* See Note on Sheet D2-55a regarding different angles.

Scale: 1/8" = 1'-0"

8818

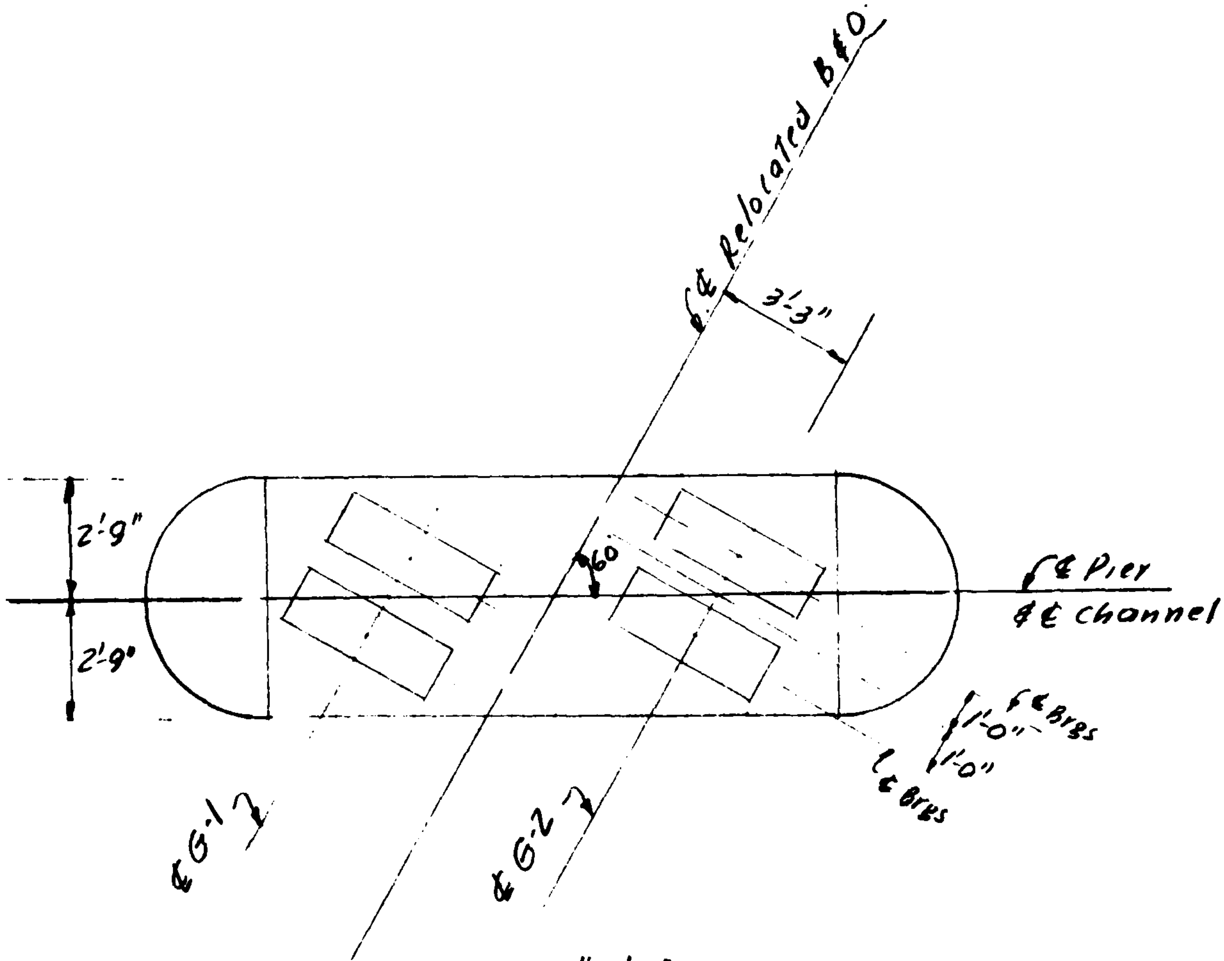
NOTE REGARDING ABUTMENT ANGLES

Normally both abutment walls would have 45° angles. However, for the abutment wall that is closest to the edge of the channel, it was felt desirable to pull the abutment wall closer to the abutment, or a 60° angle instead of a 45° angle. The 15° difference would not affect the cost appreciably. As the top of the abutment wall slopes down from the bridge, pulling the abutment wall in towards the abutment would be exposing less of the riprap behind the wall to channel flow. Although the riprap is designed for the expected channel velocities, the channel slope behind the wall is an area of expected turbulence. Although the footing for the abutment wall is below channel grade, it was felt desirable not to have the footing close to the edge of the channel for the entire length of the abutment wall. A 45° abutment deflection is standard when a bridge is normal to the channel centerline. When there is a substantial skew, the geometry at the abutments sometimes makes different wall skews desirable. The selection of the 60° angle instead of the 45° angle was basically an engineering judgment decision.

Gannett Fleming Corddry and Carpenter, Inc.
Harrisburg, Pa.

SUBJECT Big creek R.R. Bridge — Spur Line FILE NO. ____
SHEET NO. ____ OF ____ SHEETS
FOR ____
COMPUTED BY JRS DATE 1-9-79 CHECKED BY RSM DATE 1-10-79

Pier Location:



scale: 1/4" = 1'-0"

Span length: (along ℄ Relocated B&O):
℄ Brgs Abutment 1 to ℄ Brg Abutment 2:
$L = (116.5 \div \sin 60^\circ) + 9.1782 \times 2 = 152.8790 \approx 152'-10\tfrac{1}{2}"$
℄ Brgs Abutment to ℄ Pier = 76.4395'
Max span length = 76.4395 + 3.25 × tan 30° − 1.0 = 77.3159'
Min span length = 76.4395 − 3.25 × tan 30° − 1.0 = 73.5631'
Note: For superstructure design see Main Line D2-56

8313

GANNETT FLEMING CORDDRY AND CARPENTER, INC. HARRISBURG, PA.	SUBJECT Big creek R.R. Bridge Spur Line FILE NO. SHEET NO. OF SHEETS FOR COMPUTED BY JRS DATE 1-17-79 CHECKED BY RSM DATE 1-18-79

ABUTMENT DESIGN:

Abutment #2 : Top of rail EL = 621.5 (±)

Abutment #1 . Top of rail EL = 621.5 + 153 × 0.00643 = 622.5 (±)

Top of footing EL : Abutment #2 = 596.5 (±)

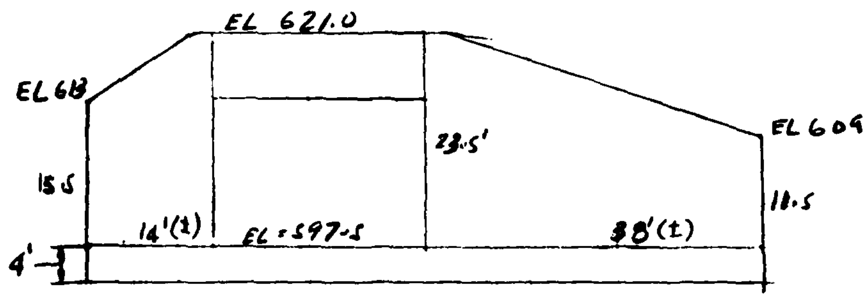
Abutment #1 : 597.5 (±)

Abutment #2 height = 621.5 − 596.5 − 1.5 = 23.5'

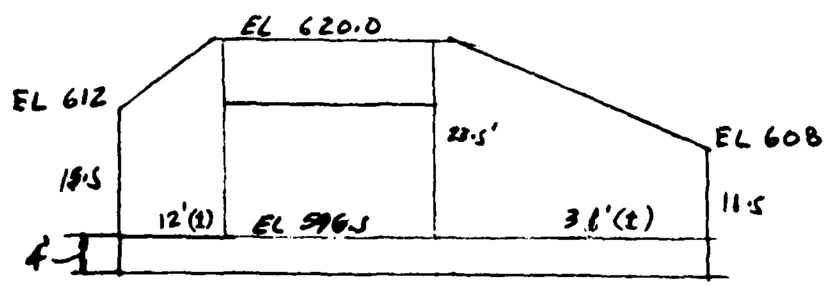
(top of backwall to top of foot)

Abutment #1 = 622.5 − 597.5 − 1.5 = 23.5'

Max height water EL = 612.5



ABUTMENT 1 : STA 114+60 (±)



ABUTMEN 2 : STA 116+13 (±)

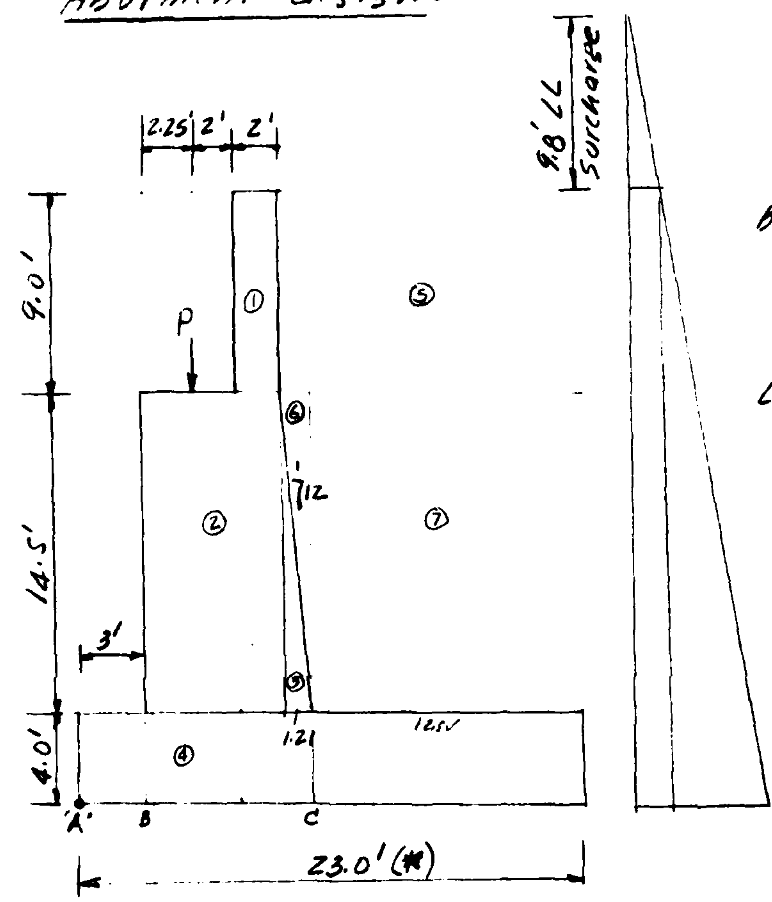
D2-57

6819

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT: Big ~~:~~ reek R.R. Bridge, Spur Line FILE NO. ____
SHEET NO. ____ OF ____ SHEETS
FOR ____
COMPUTED BY JRS DATE 1-23-79 CHECKED BY SEM DATE 1-24-78

Abutment design:



Backwall height = 9'

DL Reaction = $\frac{70}{24}$ = 2.92 k/l

LL Reaction = $\frac{486}{24} \times \frac{72}{80}$ = 18.23 k/l

* larger than required in order to fit wingwall footings.

Earth pressure:

9.8×0.035×27.5	=	9.43	× 13.75	=	129.7
$\overline{27.5}^2$×0.035×0.5	=	13.23	× 9.17	=	121.4
		22.66			251.1

Resisting Moment about "A"

①: 2×9.0×0.15	=	2.70	× 8.25	=	22.8
②: 6.25×14.5×0.15	=	13.59	× 6.125	=	83.3
③: 1.21×14.5×0.5×0.15	=	1.31	× 9.65	=	12.7
④: 23.0×4.0×0.15	=	13.80	× 11.5	=	158.7
⑤: 13.75×9.0×0.105	=	12.99	× 16.125	=	209.5
⑥: 1.21×14.5×0.5×0.105	=	0.92	× 10.06	=	9.3
⑦: 12.54×14.5×0.105	=	19.09	× 16.73	=	319.4
DL	=	2.92	× 5.25	=	15.3
Total DL =		67.32			831.0

DL+LL:

	67.32			831.0
LL =	18.23	× 5.25	=	95.7
	85.55			926.7

D2-58

8313

Abut. design (cont.)

$F.S(\text{sliding}) = 67.32 \times 0.6 \div 22.66 = 1.78$

Resultant at: $(831 - 251.1) \div 67.32 = 8.61 > \frac{B}{4}$ DL only

: $(926.7 - 251.1) \div 85.55 = 7.94$ DL+LL

$e_{DL} = \frac{23.0}{2} - 8.61 = 2.88$ $\quad$ $e_{DL+LL} = \frac{23.0}{2} - 7.94 = 3.56$

$q_{max} = \frac{67.32}{23}\left(1 + \frac{6 \times 2.88}{23}\right) = 5.12\ ^{k}/_{SF} < 10$ ok $\quad$ $q_{max} = \frac{85.55}{23}\left(1 + \frac{6 \times 3.56}{23}\right) = 7.17\ ^{k}/_{SF} < 10$ ok

$q_{min} = 0.73\ ^{k}/_{SF}$ $\quad$ $q_{min} = 0.27\ ^{k}/_{SF}$

Toe design: Soil pressure at face of abutment (B) $= 0.27 + 6.9 \times \frac{20}{23} = 6.27$

	V_B		M_B	
$-4.0 \times 0.15 \times 3.0$	$= -1.8$	$\times 1.5$	$= -2.7$	$A_s = \frac{28.2}{1.44 \times 44.5} = 0.44$ Use #6@12
6.27×3.0	$= 18.8$	$\times 1.5$	$= 28.2$	$A_s = 0.44$
$0.9 \times 3.0 \times 0.5$	$= 1.3$	$\times 2.0$	$= 2.7$	$\Sigma_o = \frac{18.3}{0.35 \times 7/8 \times 44.5} = 1.34$ $\Sigma_o = 2.4$
	18.3		28.2	

Heel design: soil pressure at "C": $0.73 + 4.39 \times \frac{12.54}{23.0} = 3.12$ DL only

$= 0.27 + 6.9 \times \frac{12.54}{23.0} = 4.03$ DL+LL

	V_C		M_C	
$4.0 \times 0.15 \times 12.54$	$= 7.5$	$\times 6.27 =$	47.2	
$23.5 \times 0.105 \times 12.54$	$= 30.9$	$\times 6.27 =$	194.0	$A_s = \frac{121.2}{1.44 \times 45.5} = 1.85$
-0.73×12.54	$= -9.2$	$\times 6.27 =$	-57.4	
$-2.39 \times 12.54 \times 0.5$	$= -15.0$	$\times 4.18 =$	-62.6	$\Sigma_o = \frac{14.2}{0.165 \times 7/8 \times 45.5} = 2.16$
	14.2		121.2	

#9 bar $u = 0.165$ $\quad$ Use #9@6"

V @ "d" from "C": $d = 3.79$ $\quad$ $A_s = 2.0$

$q = 0.73 + 4.39 \times \frac{8.75}{23.0} = 2.40$ $\quad$ $\Sigma_o = 7.1$

$V = (4.0 \times 0.15 + 23.5 \times 0.105) \times \underset{26.8}{8.75} - \underset{6.4}{0.73 \times 8.75} - \underset{7.3}{1.67 \times 8.75 \times 0.5} = 13.1$

$v_c = \frac{13.1}{12 \times 45.5} = 0.024 < 0.06$

Stem design: See Main Line Abutment

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

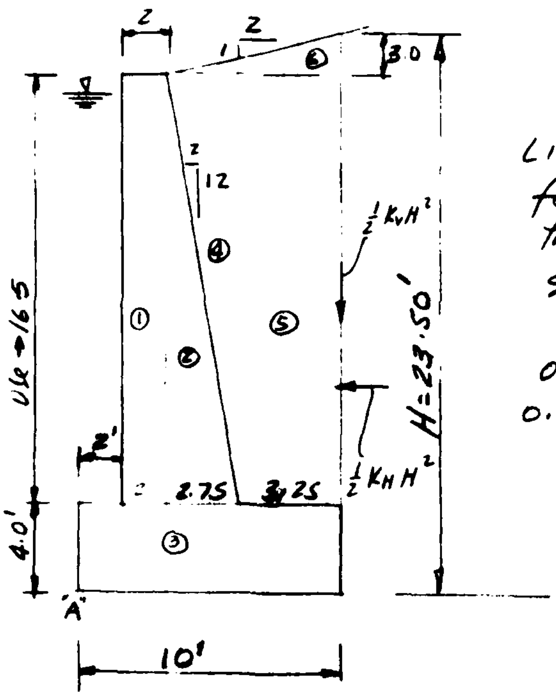
SUBJECT: Big Creek R.R. Bridge — Spur Line
FILE NO. ____ SHEET NO. ____ OF ____ SHEETS
FOR ____
COMPUTED BY: JKS DATE: 1-16-79 CHECKED BY: RSM DATE: 1-18-79

Abutment design (cont.)

Wing Wall design:

1) Max Height: see Main Line Wing walls

2) Min. Height: For 45° skew angle use backfill slope 2:1
use backfill material type 1



$K_V = 0.018$ (From AREA 8-5-17)
$K_H = 0.04$

Live load surcharge: distance from footing to edge of tie is greater than height of wall. (neglect LL surcharge)

Overturning Moment:
$0.04 \times 23.5^2 \times 0.5 = 11.0 \quad \times 7.83 = 86.2$

F.S (sliding) $= \frac{28.28 \times 0.6}{11.0} = 1.54$

Resisting Moments:

① = 2 × 16.5 × 0.15 =	4.95	× 3.0 =	14.9
② = 2.75 × 16.5 × 0.5 × 0.15 =	3.40	× 4.92 =	16.7
③ = 10.0 × 4.0 × 0.15 =	6.00	× 5.0 =	30.0
④ = 2.75 × 16.5 × 0.5 × 0.105 =	2.38	× 5.83 =	13.9
⑤ = 3.25 × 16.5 × 0.105 =	5.63	× 8.38 =	47.2
⑥ = 3.0 × 6.0 × 0.5 × 0.105 =	0.95	× 8.0 =	7.6
$\frac{1}{2}K_V H^2 = 0.5 \times 0.018 \times 23.5^2 =$	4.97	× 10.0 =	49.7
	28.28		180.0

Resultant at:
$x = \frac{180.0 - 86.2}{28.28} = 3.32 > B/4$ ok.

8312

Wing wall (Cont)

Check Buoyancy: assume High water at top of wing
$\gamma' = 0.06$

① thru ③	= 14.35	= 61.6
① thru ③ $= 14.35 \times \frac{62.4}{150}$	= -5.97	= -25.6
④ & ⑤ : $8.01 \times \frac{0.06}{0.105}$	= 4.58	= 34.9
⑥ :	= 0.95	= 7.6
$V = 4.97 \times \frac{0.06}{0.105}$	= 2.84	= 28.4
	16.75	106.9

Overturning: $0.04 \times \overline{23.5}^2 \times 0.5 \times \frac{0.06}{0.105} = 6.31 \times 7.83 = 49.4$

F.S. (sliding) $= \frac{16.75 \times 0.6}{6.31} = 1.59$ ok

Resultant at $= (106.9 - 49.4) \div 16.75 = 3.43$
$> B/4$

Max Soil pressure:
$x = 3.32 \quad e = 5.0 - 3.32 = 1.68$

$p = \frac{28.28}{10} \pm \frac{28.28 \times 1.68 \times 6}{\overline{10}^2} = 2.83 \pm 2.85 = 5.68\ ^{k}/_{SF} < 10.0$

Min $p \approx 0$

For stem and footing reinforcement see Main Line.

6818

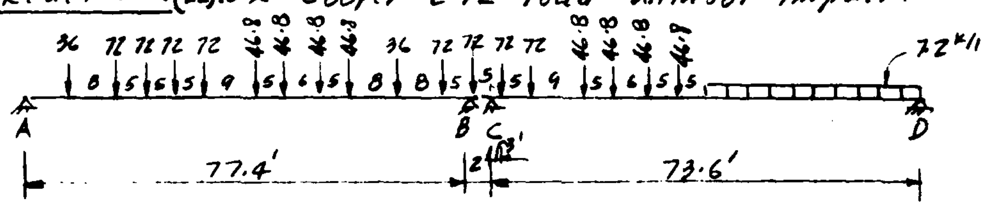
PIER DESIGN: Use Fixed bearings.

Top of rail EL = 627.0 Max. H.W EL = 612.5
bot. of Channel EL = 596.5 (at Abut. #2) and EL = 600.0 (at pier)
beam drop = rail and Tie = 1'-5"
Girder = 5'-9"
Shoe = 1-10"
9'-0"

EL 596.5
Top of footing to Top of pier = 16.5'
Assume 4' Footing

DL Reactions (DL):
R = 0.91* x 153.0 ÷ 2 = 69.6^k x 2 girders = 139.2^k
* per Girder

LL Reactions (LL): Use Cooper E72 load Without impact.



$R_B = [72(77.4 + 72.4) + 36 \times 64.4 + 46.8(56.4 + 51.4 + 45.4 + 40.4)$
$+ 72(31.4 + 26.4 + 21.4 + 16.4) + 36 \times 8.4] \div 77.4 = 379.2^k$

$R_C = [72(70.6 + 65.6) + 46.8(56.6 + 51.6 + 45.6 + 40.6)$
$+ 7.2 \times 35.6 \times 17.8] \div 73.6 = 318.8^k$

Total Reaction = 698.0^k

For stability use $R_{Total} = 1.2 \times 153.0 \div 2 = 91.8^k$

Wind Force (W & WL):

1) Wind from structure (W): 30 #/SF (Perpendicular to ℄ of the Track)
Vertical Projection = 8.0 (ft)
$R = 0.03 \times 8.0 \times 153.0 \div 2 = 18.4^k$

2) Wind on train (WL): 300 #/l (assume both spans loaded)
$R = 0.3 \times 153.0 \div 2 = 23.0^k$

8813

Pier design (cont.)

<u>Stream Current</u> (SF): (UK AASHTO 1978 interim)

$Q = 12000$ CFS

Channel Area:

$(30 + 43.5)\frac{1}{2} \times 3 = 110.25$

$116.5 \times 12.5 = 1456.25$

$31.25 \times 12.5 \times \frac{1}{2} \times 2 = 390.6$

1957.1 SF

$V = 12000 \div 1957.1 = 6.1$ ft/sec.

$P = KV^2$ $K = \frac{2}{3}$ (circular piers)

$p = (6.1)^2 \times \frac{2}{3} = 25$ #/SF

$F = 25 \times 12.5 \times 5.5 = 1.8^k$ $M_B = 1.8 \times 13.25 = 24^{k\text{-}1}$

<u>Effect of Ice</u>: (UK AASHTO 1978 interim)

thickness of Ice in contact $= 6'' = t$

$F = C_n\, p\, t\, w \times C_1$

$C_n = 1.0$ (inclination of nose to vertical $= 0°$)

$p = 200$ psi (break-up at melting temperature and Ice moves in large pieces)

$W = 66''$ $C_1 = 0.8$ ($b/t = \frac{66}{6} = 11.0 > 4$)

$F_B = 1.0 \times 200 \times 6 \times 66 \times 0.8 = 63.4^k$ (longitudinal direction)

$F_0 = 63.4 \times 0.15 = 9.5^k$ (overturning direction

Moments at bot. of pier: applied forces at EL 612.0

$M_B = 19.5 \times 63.4 = 1236^{k\text{-}1}$

$M_0 = 19.5 \times 9.5 = 185^{k\text{-}1}$

Pier design (cont)

Longitudinal Force (LF): assume continuous rail and full long force resisted by Fixed bearings.

$R_B = (36 + 72 \times 4 + 46.8 \times 4 + 36 + 72 \times 2) \times 0.15 \times \frac{77.4}{1200} = 6.7$

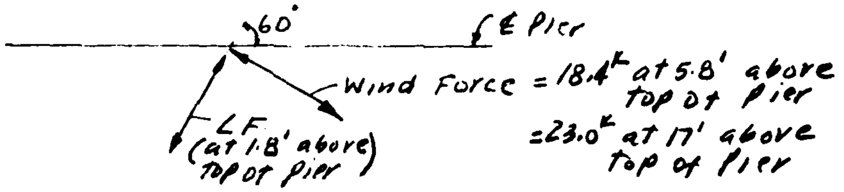
$R_C = (72 \times 2 + 46.8 \times 4 + 7.2 \times 35.6) \times 0.15 \times \frac{73.6}{1250} = 5.4$

TOTAL $LF = 12.1^k$

Footing Design:

set footing on sound rock ⊥ to ℄ Track

Allow bearing pressure $= 5 \frac{ton}{SF}$



Wind from Pier: assume: { length = 18.5' / Width = 5.5 } and Wind ⊥ to Track

Wind // to ℄ pier $= 0.03 \times \cos 30° \times 5.5 \times 13.0 = 1.9^k$ $M_0 = 1.9 \times 14.0 = 27^{k\text{-}1}$

Wind ⊥ to ℄ pier $= 0.03 \times \sin 30° \times 18.5 \times 13.0 = 3.6^k$ $M_0 = 3.6 \times 14.0 = 50^{k\text{-}1}$

Forces and Moments at bot. of footing:

Max Forces in overturning direction:

$F_0(W) = 18.4 \sin 30° = 9.2^k$ $F_0(WL) = 23.0 \times \sin 30° = 11.5^k$ $F_0(LF) = 12.1 \times \sin 60° = 10.5^k$

$M_0 = 9.2 \times 26.3 + 11.5 \times 37.5 + 10.5 \times 22.3 = 907^{k\text{-}1}$ $F_0(Total) = 31.2^k$

$F_B(W) = 18.4 \times \sin 60° = 15.9^k$ $F_B(WL) = 23.0 \times \sin 60° = 19.9^k$ $F_B(LF) = 12.1 \times \sin 30° = 6.1^k$

$M_B = 15.9 \times 26.3 + 19.9 \times 37.5 - 6.1 \times 22.3 = 1028^{k\text{-}1}$ $F_B(Tot) = 29.7^k$

Max Forces in Bent direction: $F_0 = 9.2 + 11.5 - 10.5 = 10.2^k$

$M_0 = 9.2 \times 26.3 + 11.5 \times 37.5 - 10.5 \times 22.3 = 439^{k\text{-}1}$

$F_B = 15.9 + 19.9 + 6.1 = 41.9^k$ $M_B = 15.9 \times 26.3 + 19.9 \times 37.5 + 6.1 \times 22.3 = 1300^{k\text{-}1}$

Axial load: assume $20 \times 9.5 \times 4$ Footing

Wt of shaft $= 13.0 \times 16.5 \times 5.5 \times 0.15 + \frac{3.14 \times 5.5^2}{4} \times 16.5 \times 0.15 = 235.7^k$

Wt of footing $= 20 \times 9.5 \times 4 \times 0.15 = 114.0^k$

Total axial load: 1) DL only $= 139.2 + 235.7 + 114.0 = 488.9$

2) DL + LL $= 488.9 + 698.0 = 1186.9^k$

Wt of Cover $= (20 \times 9.5 - 13.0 \times 5.5 - \frac{3.14 \times 5.5^2}{4}) \times 3.5 \times 0.12 = 40^k$ 02-64

Foot design (cont.) : Use the following loading conditions:

Group I: DL + LL + B* + SF

$P_{DL} = 488.9 + 40 - (235.7 + 114.0) \times \frac{0.062}{0.15} - 40 \times \frac{0.062}{20 \times 0.12} = 364.2^k$

Total $P = 364.2 + 698.0 = 1062.2^k$

$M_O = 0$ $M_B = 24^{k\text{-}1}$ Group Ia: DL + LL $P = 1226.9^k$ $M_B = M_O = 0$

Group II: DL + B + SF + W :

$P = 364.2^k \div 1.25 = 291^k$

$M_B = 24 + 418 = 442 \div 1.25 = 354^{k\text{-}1}$

$M_O = 242 \div 1.25 = 194^{k\text{-}1}$

$e_O/9.5 = 0.07$ $e_B/20 = 0.06$ Case I

FOR NOTE ON LOADING CONDITIONS SEE SHEET D2-66

Group III: DL + LL + B + SF + 0.3W + WL + LF

$P = 1062.3 \div 1.25 = 850^k$

$M_B = 24 + 418 \times 0.3 + 746 - 136 = 759 \div 1.25 = 608^{k\text{-}1}$

$M_O = 242 \times 0.3 + 431 + 234 = 738 \div 1.25 = 590^{k\text{-}1}$

$e_O/9.5 = 0.07$ $e_B/20.0 = 0.04$ Case I

Group IIIa: DL + LL + 0.3W + WL + LF

$P = 488.9 + 40 + 698.0 = 1226.9 \div 1.25 = 982^k$

$M_B = (759 - 24 + 27 \times 0.3) \div 1.25 = 594^{k\text{-}1}$

$M_O = 738 + 50 \times 0.3 = 753 \div 1.25 = 602^{k\text{-}1}$

$e_O/9.5 = 0.06$ $e_B/20.0 = 0.03$ Case I

Group VIII: DL + LL + B + SF + Ice

$P = 1062.2 \div 1.4 = 759^k$

$M_O = 185 \div 1.4 = 132^{k\text{-}1}$

$M_B = (1236 + 24) \div 1.4 = 900^{k\text{-}1}$

$e_O/9.5 = 0.02$ $e_B/20.0 = 0.06$ Case I

Group IX: DL + B + SF + W + Ice

$P = 364.2 \div 1.5 = 243^k$

$M_B = (442 + 1236) \div 1.50 = 1119^{k\text{-}1}$

$M_O = (242 + 185) \div 1.50 = 285^{k\text{-}1}$

$e_O/9.5 = 0.12$ $e_B/20.0 = 0.23$ Case II

For soil pressures of footings under doubly eccentric loads see AREA fig 6, p 8-3-12

* B = Boyancy

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GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Big Creek RR Bridge FILE NO.
Spur Line SHEET NO. OF SHEETS
FOR
COMPUTED BY JRS DATE 1-11-79 CHECKED BY RJM DATE 1-16-79

Foot. design (Cont.)

Max bearing pressure:

$A = 9.5 \times 20 = 190 \qquad S_0 = \frac{9.5^2 \times 20}{6} = 301 \qquad S_B = \frac{20^2 \cdot 9.5}{6} = 633$

Group IA: $p = \frac{1226.9}{190} = 6.46\ ^{K}/_{SF}$

Group IIIa: $p = \frac{982}{190} + \frac{594}{633} + \frac{602}{301} = 5.17 + 0.94 + 2.00 = 8.11\ ^{K}/_{SF} < 10.0$

Group IX: $K = 3.75$

$p = \frac{3.75 \times 243}{190} = 4.80\ ^{K}/_{SF}$

Use $20' \times 9.5' \times 2'^{(*)}$ Footing.

footing depth: try 2': Use $\begin{cases} f'_c = 3000 \text{ psi} \\ f_s = 20000 \text{ psi} \end{cases}$

Overturning:

$8.11 \times 2.0 = 16.2 \times 1.0 = 16.2$

$- 2.0 \times 0.15 \times 2.0 = -0.6 \times 1.0 = -0.6$

$- 3.0 \times 0.12 \times 2.0 = \underline{-0.7} \times 1.0 = \underline{-0.7}$

$V = 14.9\ ^{K}/_{'} \qquad M = 14.9\ ^{K-'}/_{'}$

$A_s = \frac{14.9}{1.44 \times 20.5} = 0.50\ ^{\square''}/_{'}$

Use # 6 @ 9" $\begin{cases} A_s = 0.59 \\ \Sigma_o = 3.1 \end{cases}$

$\Sigma_o = \frac{14.9}{0.35 \times 0.875 \times 20.5} = 2.40\ ''/_{'}$

$u = \frac{4.8\sqrt{3000}}{0.75} = 0.35$

* OK 2' footing

V_c at distance "d" is negligible

NOTE:

Group I, II, etc. refer to Loading Conditions. Loading Conditions are from the AASHTO Specification for highway bridges. In the past, this design procedure has been acceptable to the railroads. A copy of Paragraph 1.2.22, LOADING CONDITIONS from AASHTO is on Sheet 66a. This is from "Standard Specifications for Highway Bridges," 11th Edition, 1973.

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GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Big Creek R.R. Bridge FILE NO. ____
Spilline SHEET NO. ____ OF ____ SHEETS
FOR ____
COMPUTED BY FF DATE 9-20-79 CHECKED BY ____ DATE ____

Refer to Note on Sheet D2-66. The following is from AASHTO:

1.2.22 — LOADING COMBINATIONS

The following Groups represent various combinations of loads and forces to which a structure may be subjected. Each part of such structure, or the foundation on which it rests, shall be proportioned for all combinations of such of these forces as are applicable to the particular site or type, and at the percentage of the basic unit stress indicated for the various groups except that no increase in allowable unit stresses shall be permitted for members or connections carrying wind loads only. See Articles 1. 2. 1 to 1. 2. 21 for loads and forces.

The maximum section required shall be used.

		Percentage of Unit Stress
Group I	=D+L+I+E+B+SF	100%
Group II	=D+E+B+SF+W	125%
Group III	=Group I+LF+F+30% W+WL+CF	125%
Group IV	=Group I+R+S+T	125%
Group V	=Group II+R+S+T	140%
Group VI	=Group III+R+S+T	140%
Group VII	=D+E+B+SF+EQ	133⅓%
Group VIII	=Group I+ICE	140%
Group IX	=Group II+ICE	150%

D	= Dead Load
L	= Live Load
I	= Live Load Impact
E	= Earth Pressure
B	= Buoyancy
W	= Wind Load on Structure
WL	= Wind Load on Live Load—100 pounds per linear foot
LF	= Longitudinal Force from Live Load
CF	= Centrifugal Force
F	= Longitudinal force due to friction or shear resistance (elastomeric bearings).
R	= Rib Shortening
S	= Shrinkage
T	= Temperature
EQ	= Earthquake
SF	= Stream Flow Pressure
ICE	= Ice Pressure

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Column Design:

For Note on Loadings, See D2-66

Group IA: $P = 235.7 + 139.2 + 698 = 1073^k$ $M_B = M_0 = 0$

Group I: $P = 235.7 + 139.2 + 648 - 235.7 \times \frac{0.062}{0.15} = 975.4^k$
$M_0 = 0$ $M_B = 1.8 \times 9.25 = 17^{k\cdot\prime}$

Group II: $P = 277.9 \div 1.25 = 222^k$
$M_B = 17 + 15.9 \times 22.3 = 371 \div 1.25 = 297^{k\cdot\prime}$ $e = 1.34$ $e/18.5 = 0.07$
$M_0 = 9.2 \times 22.3 = 205 \div 1.25 = 164^{k\cdot\prime}$ $e = 0.74$ $e/5.5 = 0.13$

Group III: $P = 139.2 + 698 + 235.7 - 235.7 \times 0.062/0.15 = 975 \div 1.25 = 780.7^k$
$M_B = 17 + 0.3 \times 354 + 19.9 \times 33.5 - 6.1 \times 18.3 = 678 \div 1.25 = 542$ $e/18.5 = 0.04$
$M_0 = 0.3 \times 205 + 11.5 \times 33.5 + 10.5 \times 18.3 = 639 \div 1.25 = 511$ $e/5.5 = 0.12$

Group IIIa: $P = 235.7 + 139.2 + 698 = 1072.9 \div 1.25 = 858.3^k$
$M_B = 0.3(354 + 1.9 \times 10) + 667 - 112 = 667 \div 1.25 = 533$ $e/18.5 = 0.03$
$M_0 = 0.3(205 + 3.6 \times 10) + 385 + 192 = 649 \div 1.25 = 519$ $e/5.5 = 0.11$

Group VIII: $P = 975.9 \div 1.40 = 697.0^k$
$M_B = 17 + 63.4 \times 15.5 = 1000 \div 1.40 = 714$ $e/18.5 = 0.06$
$M_0 = 9.5 \times 15.5 = 147 \div 1.4 = 105$ $e/5.5 = 0.03$

Group IX: $P = 277.9 \div 1.5 = 185.3$
$M_B = 371 + 983 = 1354 \div 1.5 = 902$ $e = 4.87$ $e/18.5 = 0.26$
$M_0 = 205 + 147 = 352 \div 1.5 = 235$ $e = 1.26$ $e/5.5 = 0.23$

Min concrete section with 1% of reinforc. steel:
Actual column dimensions: $5.5' \times 13'$ (*)
* without circular portions.
ratio $W/T = 13.0/5.5 = 2.4$
Try $34'' \times 82''$ section $A = 2788\ in^2$
$A_s = 0.01 \times 2788 = 27.88\ in^2$ Try 36 #8 bars $A_s = 28.44\ in^2$ say $\rho = 0.01$
Use $f'_c = 3000$ psi and $f_s = 20000$ psi $F_y = 40000$ psi
in all Groups (except IX) $\Sigma\ e/t < 0.5$

$$f_c = \frac{N}{A_g}\left[\frac{1 + \Sigma\, De/t}{1 + (n-1)\rho}\right] = \text{combined fiber stress in compression}$$

assume $D = 5$

$$\text{Max. allowable compressive stress} = f_p = f_a\left[\frac{1 + \Sigma \frac{De}{t}}{1 + C\,\Sigma \frac{De}{t}}\right]$$

$$f_a = \frac{0.225 f'_c + f_s \rho}{1 + (n-1)\rho} \times 0.8 \quad \text{and} \quad C = \frac{f_a}{0.4 f'_c}$$

Column design (cont.)

$$f_a = \frac{0.225 \times 3.0 + 20.0 \times 0.01}{1 + 11 \times 0.01} \times 0.8 = 0.63$$

$$C = \frac{0.63}{0.4 \times 3.0} = 0.525$$

Group IA: $\Sigma \frac{De}{t} = 0$ $\qquad f_c = \frac{1073}{34 \times 82}\left(\frac{1}{1 + 11 \times 0.01}\right) = 0.343$

$f_p = f_a = 0.63 > f_c$ ok

Group IIIa: $\Sigma \frac{De}{t} = 5(0.09 + 0.21) = 1.5$ $\qquad f_c = \frac{858.3}{34 \times 82}\left(\frac{1 + 1.5}{1.11}\right) = 0.693$

$e/6.83 = 0.09$

$e/2.83 = 0.21$ $\qquad f_p = 0.63\left[\frac{1 + 1.5}{1 + 0.525 \times 1.5}\right] = 0.881 > f_c$ ok

Group II: $\Sigma \frac{De}{t} = 5(0.20 + 0.26) = 2.30$ $\qquad f_c = \frac{222}{34 \times 82}\left(\frac{1 + 2.30}{1.11}\right) = 0.237$

$e/6.83 = 0.29$

$e/2.83 = 0.36$

0.46 $\qquad f_p = 0.63\left[\frac{3.30}{1 + 0.525 \times 2.30}\right] = 0.942 > f_c$ ok

Group IX: $\Sigma \frac{e}{t} > 0.5$

neglect tensile strength of the concrete and use 0.003 max. strain at the extreme compression fiber.
Assume strain in reinforcement and concrete directly proportional to the distance from the N.A.
run program UCD: Load-Moment interaction curve and use 35% of the combined flexural and axial load capacity

$$0.1 f'_c A_g \times 0.35 = 836 \times 0.35 = 293^k > P \qquad \frac{M_x}{M_{nx}} + \frac{M_y}{M_{ny}} \le 1$$

Group IX: $\frac{902}{2182} + \frac{235}{1198} = 0.41 + 0.20 = 0.61 < 1.0$

Lateral ties: use #4 bars

Spacing $= 16 \times 1.0 = 16.0$
$48 \times \frac{1}{2} = 24.0$ } use 16"
Min column dimension $= 66$

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```
     edit ucd intt
EDIT  run
WIDTH, THICKNESS, FC CONC, FY STEEL, NO, BAR LOC, NA INCR
?      34 82 3 40 6 6
INPUT   6 PAIRS OF DISTANCES AND AS (MAX. 4 PAIRS PER LINE
?      3 4.74  18.2 4.74  33.4 4.74  48.6 4.74
?      63.8 4.74  79 4.74

POINTS ON LOAD-MOMENT INTERACTION CURVE
COLUMN W=  34.0 IN    CONC FC=  3.00 KSI
       T=  82.0 IN  RFINF FY= 40.00 KSI

REINFORCEMENT DISTANCE(IN) AND AS(SQ IN)
     DIS      AS        DIS      AS        DIS      AS        DIS      AS
     3.00    4.74      18.20    4.74      33.40    4.74      48.60    4.74
    63.80    4.74      79.00    4.74

NOTE: PHI=1    COMPRESSION IS PLUS
     I(CONC)=     75.338 FT4     I(REINF)=     0.9242 FT4
     EI(CONC)/5+EI(STEEL)=    10633517 K-FT2
     0.1*FC*AG=    836.4  K.   AS/AG= 0.0102

N-AXIS(IN)   FORCE(K)   MOMENT(KF)   ECCEN(FT)
              8174.5        0.0
  109.000     8079.8      276.3        0.034
  103.000     8048.3      358.2        0.045
   97.000     8012.9      450.1        0.056
   91.000     7581.8     1815.3        0.239
   85.000     7081.0     3187.8        0.450
   79.000     6568.3     4393.5        0.669
   73.000     6056.1     5412.7        0.894
   67.000     5517.1     6297.8        1.142
   61.000     4956.0     7033.1        1.419
   55.000     4360.2     7612.3        1.746
```

CMG: RIM (…)

Big Creek R.R Bridge
Spur Line

Bent direction

NOTE:
This is an analysis program that analyzes a concrete section for axial load and moment. Program generates the interaction diagram.

Writeup of program at end of this Subappendix.

Bent direction (cont.)

49.000	3774.5	7880.9	2.088
43.000	3171.0	7945.8	2.506
37.000	2613.4	7710.5	2.950
31.000	2019.5	7220.4	3.575
25.000	1412.6	6408.7	4.537
19.000	836.7	5397.6	6.451
13.000	212.2	4041.5	19.046
10.456	0.1	3509.9	

$e_{II} = 4.87$ $M = 6230 \times 0.35 = 2182$ *

Chkd: RSM (1-17-79)

BALANCED DESIGN POINT

54.118	4267.7	7687.9	1.801

END OF PROGRAM UCD
EDIT

* Program based on ultimate strength design and requires longhand check for working stress design required by AREA.

e_{II} = actual eccentricity

By interpolation Ultimate Moment = 6230

.35 Factor converts moment to allowable working stress moment.

∴ $M_{all.} = 2182 > M_{actual}$ of 902 (See Sheet 02-67)

```
         run
WIDTH, THICKNESS, FC CONC, FY STEEL, NO. BAR LOC, NA INC?
?        82 34 3 40 4 6
INPUT    4 PAIRS OF DISTANCES AND AS (MAX. 4 PAIRS PER LINE
?        3 11.06  12.33 3.16  21.67 3.16  31 11.06

POINTS ON LOAD-MOMENT INTERACTION CURVE
COLUMN W=  82.0 IN    CONC FC=  3.00 KSI
       T=  34.0 IN   REINF FY= 40.00 KSI

REINFORCEMENT DISTANCE(IN) AND AS(SQ IN)
         DIS     AS        DIS     AS        DIS     AS        DIS     AS
         3.00   11.06     12.33   3.16      21.67   3.16      31.00   11.06

NOTE   PHI=1    COMPRESSION IS PLUS
       I(CONC)=     12.952 FT4     I(REINF)=     0.2157 FT4
       EI(CONC)/5+EI(STEEL)=     2065469 K-FT2
       0.1*FC*AG=    836.4  K.   AS/AG= 0.0102

N-AXIS(IN)   FORCE(K)   MOMENT(KF)    ECCEN(FT)
              8174.5         0.0
   37.000     7342.4      1037.7         0.141
   31.000     6117.0      2256.5         0.369
   25.000     4781.6      3145.0         0.658
   19.000     3398.6      3560.4         1.048
   13.000     2170.1      3263.5         1.504
    7.000      963.1      2453.5         2.547
    3.352        1.6      1407.3

BALANCED DESIGN POINT
   21.236     3847.8      3551.6         0.923

END OF PROGRAM UCD
EDIT  end
READY logoff
LOGGED OFF AT  09.11.51  01/15/79
*SESSION DURATION  00.05.25  CPU TIME USED    2766/300THS SEC.
```

Overturning direction

Chkd: RSM (1-17-79)

$e_B = 1.26$ $M = 3422 \times 0.35 = 1198^*$

* See explanation Sheet 02-70.

GANNETT FLEMING CORDDRY
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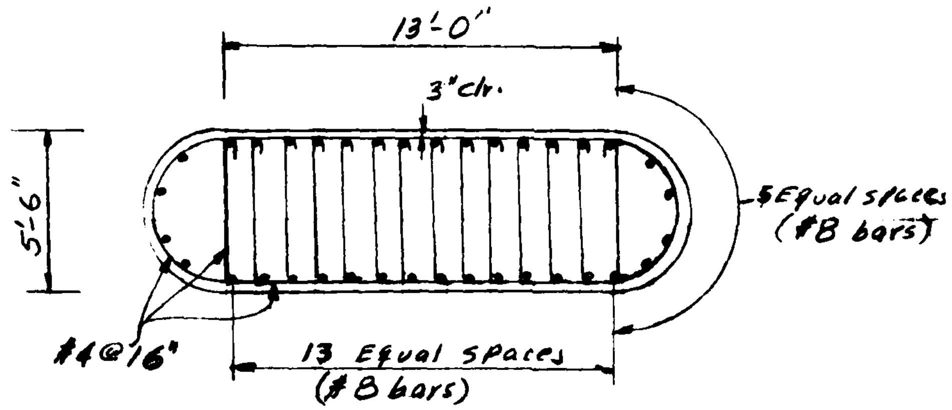
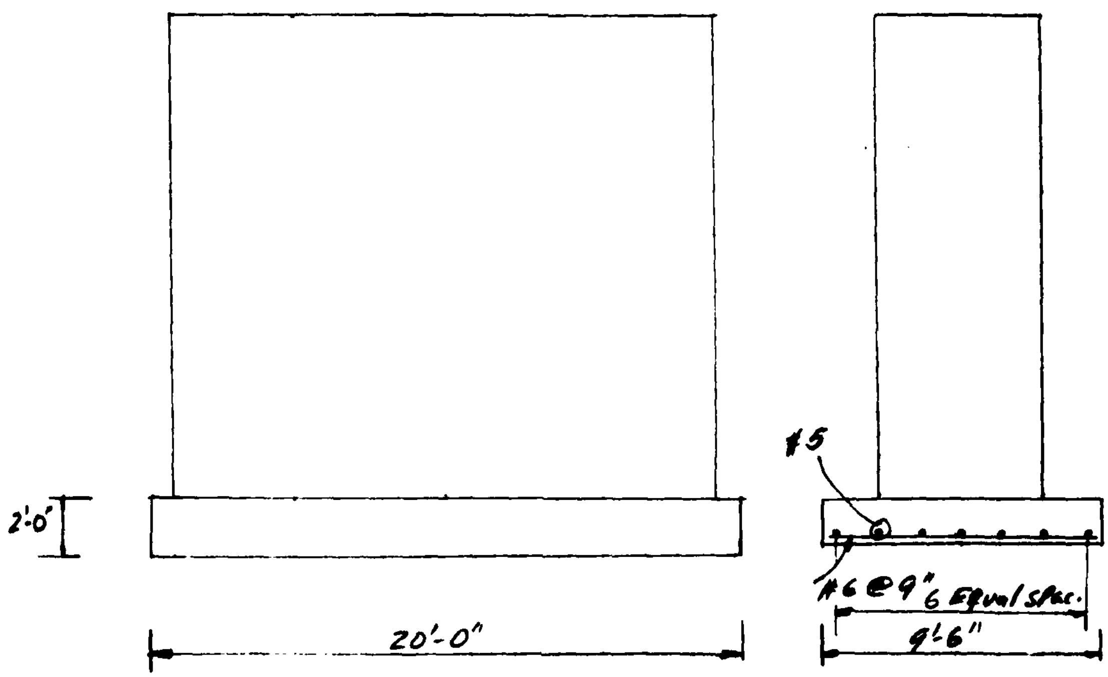
HARRISBURG, PA.

SUBJECT Big Creek R.R. Bridge FILE NO.
Spur Line SHEET NO. OF SHEETS
FOR
COMPUTED BY JRS DATE 1-15-79 CHECKED BY RSM DATE 1-17-79

Pier design (Cont.)





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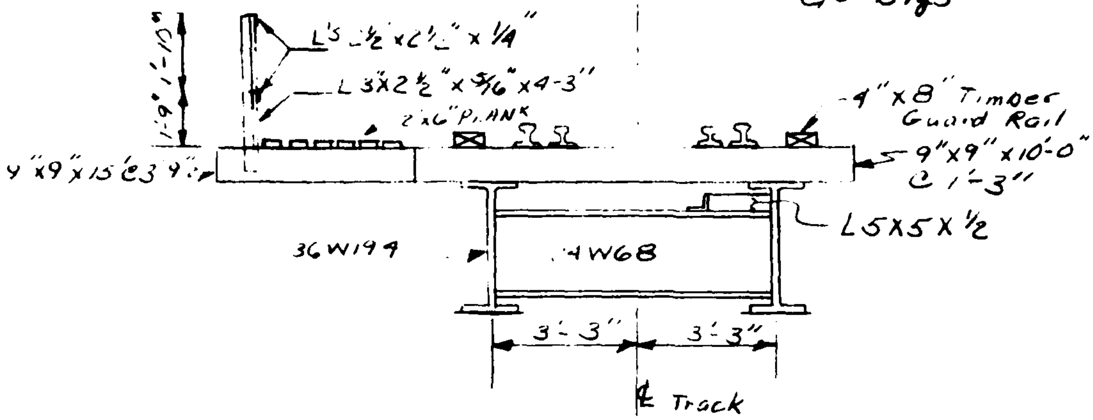
GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Big Creek R.R. Bridge FILE NO.
Temporary Structure SHEET NO. OF SHEETS
FOR U.S. Army Engineer District Buffalo
COMPUTED BY RNP DATE 1/29/79 CHECKED BY JRS DATE 2-5-79

TRESTLE BENTS DESIGN:

Span Length 26'
C/C Brgs



TYPICAL SECTION

DEAD LOADS

1) Weight of Track Rails, Inside Guard Rails, & Fastenings = 200 #/ft

"	Timber Guard Rails	0.33(0.67)(60)(2)	=	27
"	Walk way	(6)(0.17)(0.5)(60)	=	31
"	Railing	2(9.1)+8(4.25)(5.6)/26	=	15.5
"	Ties	(0.75)(0.75)(10)(60)/1.25	=	270
"	Ties	(0.75)(0.75)(5)(60)/3.75	=	45
				588.5 #/ft

2)

36W194 Girders	2(194)	=	388 #/ft
24W68 Diaphragm	(6.5)(68)/26	=	17 #/ft
5x5"x½" Lateral Bracing	4(8.93)(16.2)/26	=	22.3 #/ft
			427.3 #/ft

Total Dead Load 1+2 = 1015.8 #/ft

D.L. per Girder = 0.52 K/ft

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GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Big Creek R.R. Bridge FILE NO.
Temporary Structure SHEET NO. OF SHEETS
FOR U.S. Army Engineer District - Buffalo
COMPUTED BY RNP DATE 1/29/79 CHECKED BY JRS DATE 2-5-79

LIVE LOAD: COOPER E-80

Impact: Open Deck without Hammer Blow

$$I = \frac{100}{S} + 40 - \frac{3L^2}{1600} = \frac{100}{6.5} + 40 - \frac{3(26)^2}{1600} = 54\%$$

From "Stresses in Framed Structures" Hool & Kinne
table 3 page 144

Max. Mom		Max Shear
D.L.	$= 0.52(26)^2/8 = 43.9$ K-ft	$0.52(26)/2 = 6.76$K
L.L.	$= 406 \times 80/50 = 649.6$K-ft	$72.6 \times 80/50 = 116.2$K
I	$= 649.6 \times 0.54 = 350.8$K-ft	$116.2 \times .54 = 62.7$K
	1044 K-ft	185.7K

Max. Shear Stress

$$f_v = 185.7/(36.48)(0.77) = 6.61 \text{ KSI} < 12.5 \text{ Allow.}$$

Max. Bending Stress

$$f_b = 1044(12)/665 = 18.8 \text{ KSI}$$

Allow. Compressive Stress w/ Diaph. Spa. = 13'

$$(\ell/r_y)\ (12)13/2.56 = 60.94$$

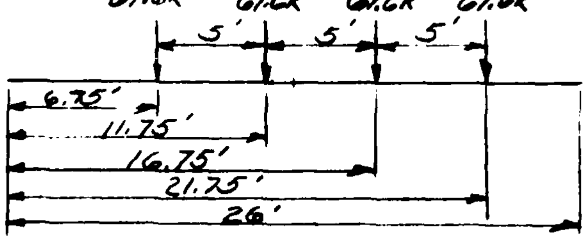
$$F_b = 20{,}000 - 0.4(60.94)^2 = 18.5 \text{ KSI} \qquad d/A_f = 2.39$$

$$F_b = 10500000/(12\times13)(2.39) = 28.2 \text{ KSI} \quad \therefore \text{ USE } 20 \text{ KSI}$$

Deflection

$$\Delta_{Allow} = L/640 = 12(26)/640 = 0.49''$$

Loading for Max. Deflection Wheel 3 1.25' Left of Center



D2-74

8313

Big Creek R.R. Bridge
Temporary Structure
U.S. Army Engineer District-Buffalo
By: RNP 1/30/79
CHKD BY: JRS 2-5-79

```
       edit dfl old
EDIT  old
SPAN(FT) WL(KIP/FT),WR(KIP/FT) ML(FT-KIP),MR(FT-KIP)
?      26.0  0  0  0  0
NO. OF "I" VALUES?
?      1
DISTANCE & "I"?
?      26.0  12100
NO. OF CONC. LDS.?
?      4
LOAD & DISTANCE?
?      61.6  5.75
?      61.6  11.75
?      61.6  16.75
?      61.6  21.75

             DEFLECTION (INCHES)
  .10 PT   .20 PT   .30 PT   .40 PT   .50 PT
  0.1039   0.1981   0.2730   0.3217   0.3392

  .60 PT   .70 PT   .80 PT   .90 PT
  0.3241   0.2773   0.2029   0.1073

             ROTATIONS(RAD.)
LEFT=  0.0033813     RIGHT= -0.0034996

DIST. TO SPECIAL POINT?
?      0

END OF PROGRAM DFL
EDIT  end
```

Max Deflection = 0.34" < Allowable 0.49"

∴ Use W 36 x 194

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HARRISBURG, PA.

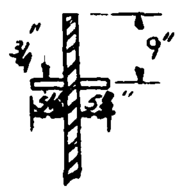
SUBJECT Big Creek R.R. Bridge — Temporary Structure FILE NO. ____ SHEET NO. ____ OF ____ SHEETS
FOR U.S. Army Engineer District - Buffalo
COMPUTED BY RVP DATE 1/30/79 CHECKED BY JRS DATE 2-5-79

Bearing Stiffeners: @ Abutments

Max Reaction = 185.7K

Try 3/4" x 5 1/2" stiffener PL

check Bearing $185.7/5(.75)(2) = 24.76\text{KSI} < 30\text{KSI}$



$A = 18(.77) + 5.5(.75)(2) = 22.11 \; \square''$

$$I_y = \frac{(.75)(5.5)^3}{12} \times 2 + 5.5(.75)(2)(3.13)^2 + (18)(.77)^3/12 = 102.3 \text{ in}^4 \quad r_y = 2.151''$$

$\frac{KL}{r} = (.75)(33.96)/2.151 = 11.84 < 15 \quad F_a = 20\text{KSI}$

$f_a = 185.7/22.11 = 8.4 \text{ KSI} < 20\text{KSI}$ OK

USE 5 1/2" x 3/4" Plate Bearing Stiffeners

Allowable shear in fillet welds = 12.5KSI

thickness = $185.7/(2)(33.96)(2)(0.707)(12.5) = 0.15''$

Use 5/16" (min size)

D2-76

6819

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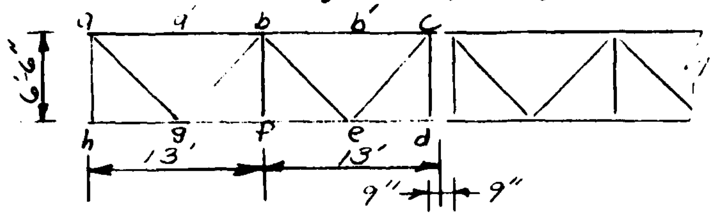
SUBJECT Big Creek R.R. Bridge FILE NO.
Temporary Structure SHEET NO. OF SHEETS
FOR U.S. Army Engineer District Buffalo
COMPUTED BY RNP DATE 2/2/79 CHECKED BY JRS DATE 2-5-79

Lateral Bracing & Diaphragms



Diaphragm: Assume wind load is carried by Lateral Bracing

Wind load on a-h = (300# 30(1.5)(5 2/12)) 13 = 6435#

Lateral Load from equipment = 1/4(80) = 20K

Max. Load to ah = 6.4 + 20 = 26.4K
try W24x68
Kl/r = (.75)(6.5)(12)/1.87 = 31.28

F_a = 21,500 - 100(31.28) = 18372 psi

f_a = 26.4/20 = 1.32 ksi OK USE W24x68

Load c ag or ec

Axial load = (6.4)(8.93)/6.5 = 8.8 k
try 5x5x1/2
Kl/r = (.75)(8.93)(12)/(.983) = 81.76

F_a = 21,500-100(81.76) = 13324

f_a = 8.8/4.75 = 1.85 ksi < 13.3 ksi OK
USE 5x5x1/2 Diagonals
weld length = 8.8/(2)(12.5)(.707)(.25) = 2" < 6.9" avail.

D2-77

6313

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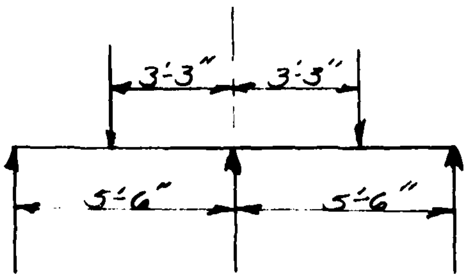
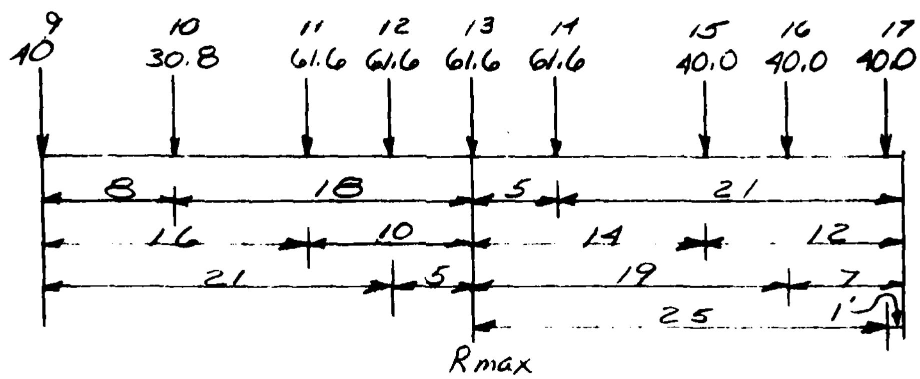
SUBJECT Big Creek R.R. Bridge FILE NO.
Temporary structure SHEET NO. OF SHEETS
FOR U.S. Army Engineer District-Buffalo
COMPUTED BY RAIC DATE 1/30/79 CHECKED BY JRS DATE 2-5-79

Bridge supported by 3 Pile Steel Bent

Bent Cap



Position of Loads for Max. Reaction on Bent Cap Place Wheel 13 over ℄ of Bent



R_{max} (L.L.+Impact) per rail $= [30.8(8) + 61.6(16) + 61.6(21) + (61.6)(21) + (40)(12) + 40(7) + 40(1)] \div 26 + 61.6 = 239.26K$

R_{max} (D.L.) $= 0.52(26) = \underline{13.5}\ K$

Total per Girder = 252.8K

Assume W 14 x 167

8818

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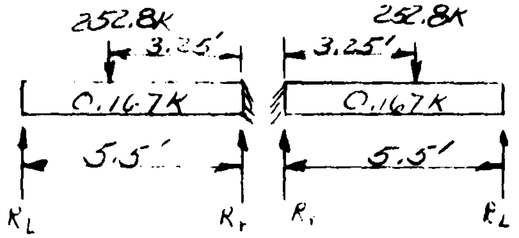
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Big Creek N.K. Bridge FILE NO.
Temporary Structure SHEET NO. OF SHEETS
FOR U.S. Army Engineer District Buffalo
COMPUTED BY KMP DATE 1/30/79 CHECKED BY JRS DATE 2-6-79



$-Mom = (0.167)(5.5)^2/8 + \frac{252.8(2.25)(3.25)}{2(5.5)^2}(2.25+5.5) =$ 234.72 k-ft

$R_L = [(.167)(5.5)(2.75) + 252.8(3.25) - 234.72] \div 5.5 = 105.45K$

$R_r = [.167(5.5)(2.75) + 252.8(2.25) + 234.72] \div 5.5 = 145.37K$

R Total = 145.37 (2) = 290.74 K

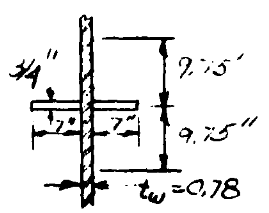
$+Mom = (0.167)(2.25)^2/2 - 105.45(2.25) = 236.84$ k-ft

Max. Bending Stress = $\frac{M}{S}$ = 236.84(12)/267 = 10.64 KSI

Max. Shear Stress = $\frac{V}{A_w}$ = 145.37/(15.12)(0.78) = 12.3 KSI < 12.5 Allowable

d/t = 19.4 < 60 No stiff. Req.

Bearing: 3/4" x 7" Plate bearing stiffeners
@ ℄ of Piles & Under long. beams



Effective length of web
25(t_w) = 19.5"

Bearing = 290.7/6.5(.75)(2) = 29.8 KSI < 30

A = 19.5(0.78) + 2(7)(.75) = 25.71 □"

$I_y = \frac{(.75)(7)^3}{12}(2) + (7)(.75)(2)(3.89)^2 + \frac{(19.5)(0.78)^3}{12} = 202.5$ in⁴

$r_y = 2.8$" $\frac{KL}{r} = 0.75(12.62)/2.8 = 3.38 < 15$ $F_a = 20$ KSI

f_a = 290.7 (2)/25.71 = 11.3 KSI < 20 KSI ∴ OK

Use 3/4" x 7" Plate bearing stiffeners

D2-79

6813

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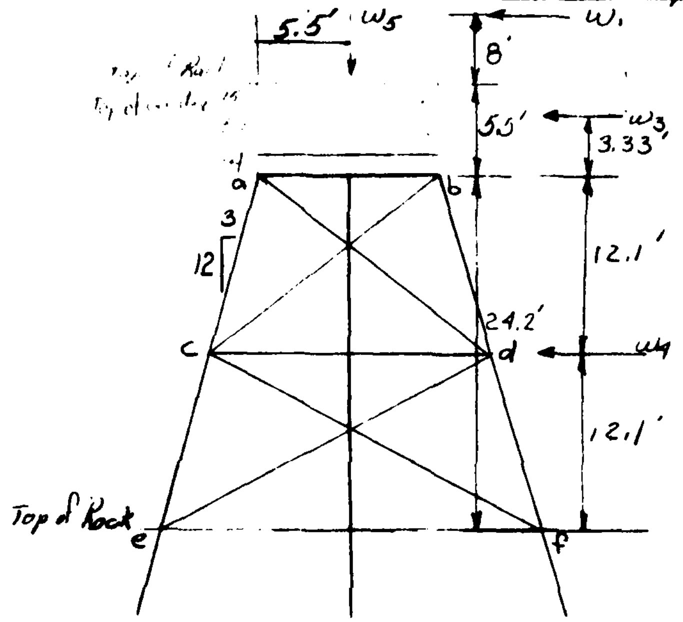
HARRISBURG, PA.

SUBJECT Big Creek R.R. Bridge FILE NO. ____
Temporary Structure SHEET NO. ____ OF ____ SHEETS
FOR U.S. Army Engineer District - Buffalo
COMPUTED BY KNP DATE 1/31/79 CHECKED BY JRS DATE 2-6-79



$w_1 = (0.3)(26) = 7.8\,K$

$w_3 = (0.03)(1.5)(\frac{52}{12})(26) = 5.07K$

$w_4 = (0.03)(21.5)(\frac{12.12+26}{12}) = 1.30\,K$

$w_5 = (1.2)(26) = 31.2\,K$

Bents (Transverse direction)

Load Per Pile: Assume each Pile carries 1/3 of Full (D.L. + L.L. + I.). Allowable Point Bearing Stress = 9 KSI

try Hp 12 x 74

Pile load capacity = 21.8 x 9 = 196 K say 100 Ton

load per Pile = 2(252.8 + .167(11)) ÷ 3 = 170 K < 196 K
USE HP 12 x 74

Assume piles only subjected to Axial compression. Longitudinal & Transverse Forces Carried by Diagonal Bracing. Assume K = 0.8

$Kl/r = 0.8(22)(12)/5.1 = 41.4 > 15$

$F_a = 21500 - 100(41.4) = 17360$ psi $f_a = 166.6/21.8 = 7.64$ KSI ok
Use HP12 x 74 Piles

check stability of bent

Overturning moment
(7.8)(37.7) + 5.07(27.53) + 1.3(12.) = 449

couple 449/23.1 = 19.4 K

23.1′

19.4K 19.4K

Uplift = 19.4 − 11.05(26)/3 − (0.074)(34) − (.167)(3)/3
−31.2/3 = −3.3K

No Uplift

check diag. ad:

Take mom. @ c (7.8)(25.6) + 5.07(15.43) = 277.91K·ft

Vert. component of ad = 277.91/17.05 = 16.3 K

Axial Force in ad = 16.3 (18.52)/12.1 = 25 K
try 6X6 X ½

f_a = 25 / 5.75 = 4.35 KSI < 20 OK

l/r = 23.4(12)/1.19 (2) = 118 < 200

weld length req. to develop capacity of member

(5.75/2)(20)/(12.5)(.375)(.707) = 17.4″

6315

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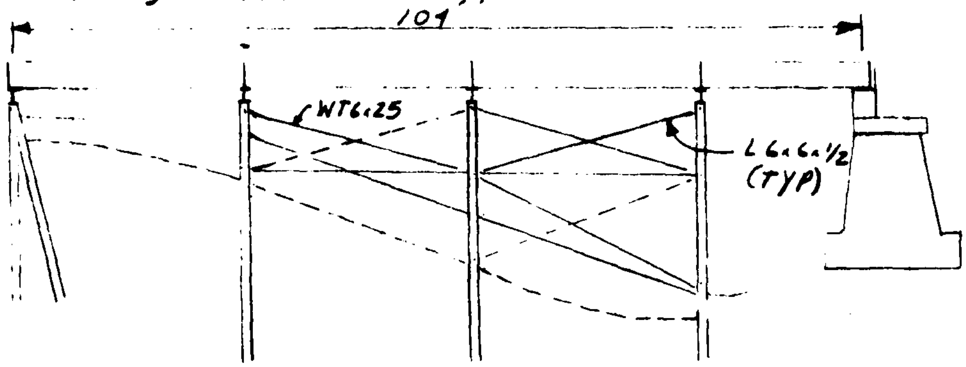
HARRISBURG, PA.

SUBJECT Big Creek R.R. Bridge FILE NO.
Temporary Structure SHEET NO. OF SHEETS
FOR U.S. Army Engineer District Buffalo
COMPUTED BY RNP DATE 2/1/79 CHECKED BY JRS DATE 2-6-79

Bents (Longitudinal direction)



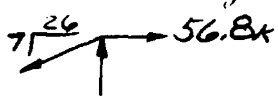
——— = Approximate North Limit of Cut e Piers & N. Bracing
- - - - = " South " & South Bracing

All three intermediate bents have fixed bearings. Girders are bolted together end to end. Assume Long. force is distributed equally to 2 bents at a time ie. bracing is not effective in comp. Worst condition occurs when load applied west to east since load is transmitted by only 3 bracing Angles.

Longitudinal Force = 15% of L.L.

L.L. = 2 Locomotives & tenders = $2(40+4(80)+4(52)) = 1136^k$
Long. Force $= (0.15)(1136) = 170.4K$ Force/Angl $= 170.4/3 = 56.8^k$

Tension in single angle bent



$T = 56.8 \frac{\sqrt{725})}{26} = 58.8\ K$

try 6X6X1/2 $l/r = (12)(\sqrt{725})/1.18 = 274 > 200$
$r_{req.} = 12\sqrt{726}/200 = 1.62$ Use WT 6X25

$f_a = 58.8 / 7.36 = 8.0$ KSI OK.

8813

Max. Unsupported length of double bracing

≈ 16'(±) min $r_{req.}$ = 12(16)/200 = 0.96"

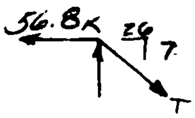
Use single 6×6×½ ∠'s

Use welded connections

Allowable Shear in fillet welds = 12.5 KSI
Use ¼" min thickness

req. length = 58.8 / (0.35)(.707)(12.5) = 27"

Max tension in double braced bent



$T = \frac{56.8}{2}\frac{\sqrt{725}}{26} = 29.4$ K

single 6×6×½ ∠ f_a = 29.4/5.75 = 5.2 KSI OK.

Brace to ℄ ; length of weld req. = 57.5/0.25(.707)(12.5) = 26"
Use ½"×10" ℄

℄ to Pile ; length of weld req.

$T_x = 29.4(26/27.8) = 27.4$ K $T_y = 29.4(7/27.8) = 7.4$ K

M@ face of Pile = 7.4(5/12) = 3.1 K-ft

Assume ¼" weld 15" long $S = \frac{(.25)(.707)(15)^2}{6}(2) = 13.2 \text{ in}^3$

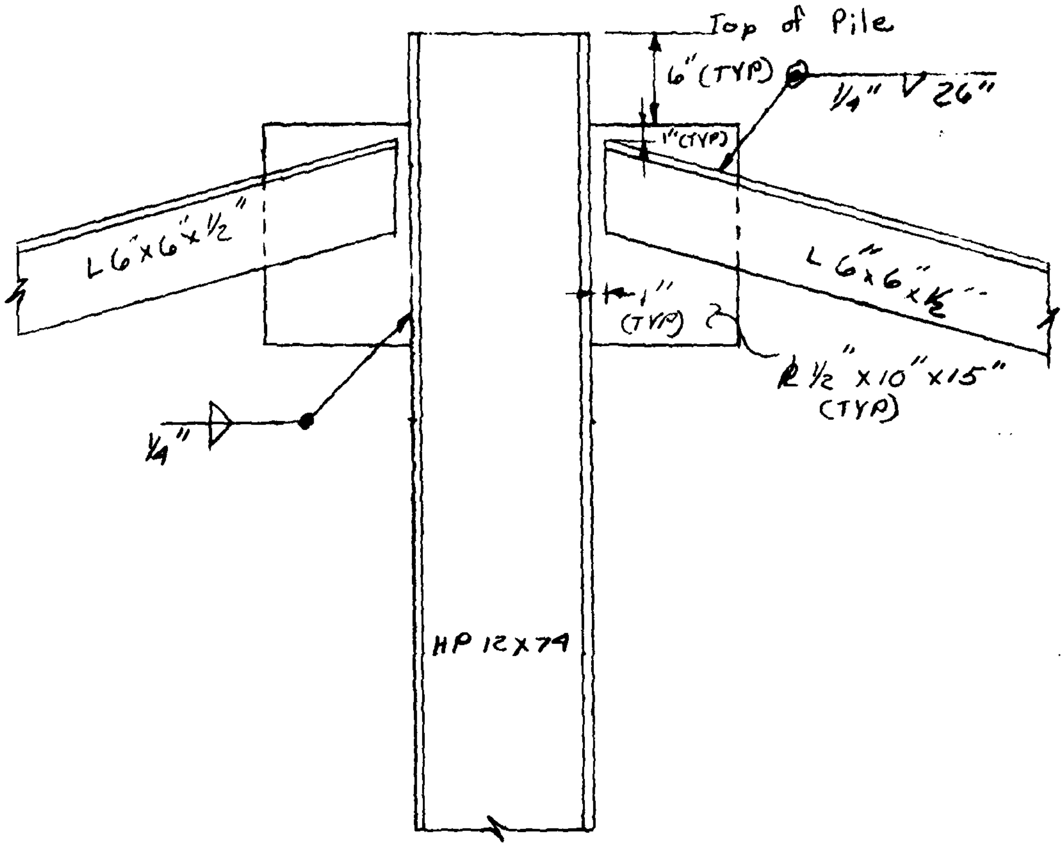
$f = (3.1)(12)/13.2 = 2.8$ KSI $\sigma_x = 27.4/2(.25)(.707)(15) + 2.8 = 7.96$ KSI

Use ½"×10"×15" ℄

D2-83

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Big Creek R.R. Bridge FILE NO.
Temporary Structure SHEET NO. OF SHEETS
FOR U.S. Army Engineer District Buffalo
COMPUTED BY KNP DATE 2/1/79 CHECKED BY JRS DATE 2-6-79



Longitudinal Bent Bracing
Scale: 1" = 1'-0"

6819

ITF PROGRAM FILE

PROGRAM **Call Name** DFL **GFC&C FILE** 216K

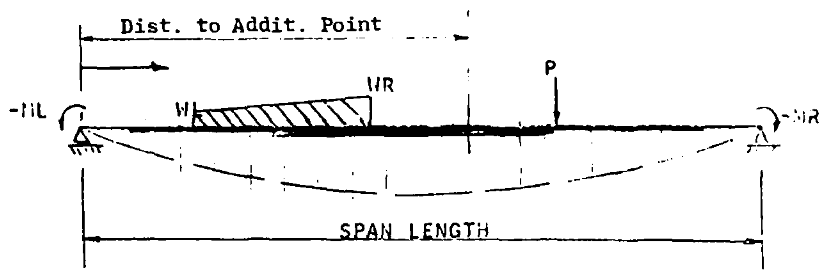
DESCRIPTION
Calculates deflections due to uniform and/or concentrated loads on a simple beam with end moments.

INPUT
Span Length (ft), Uniform Load (left, right value)
Dist. Left Reaction to start of Uniform Load.
Dist. Left Reaction to end of Uniform Load.
Left end moment (Ft-Kips) and right end moment (Ft-Kips) (minus for tension on top)
Moment of Inertia values (in^4) and corresponding end distances (ft) from left support.
Concentrated load values (kips) and corresponding distances (ft) from left support.
Distances to special points (not at 10th points of span).

OUTPUT
Deflections (inches) at 10th points of span.
Deflections at additional requested points
Rotations (plus = clockwise; minus = counterclockwise

FEATURES
Maximum Number of moments of Inertia = 20
Maximum Number of Concentrated Loads = 25
Input No. of concentrated Loads as 0 for no concentrated loads.

SAMPLE RUN
See Next Sheet...



REV1 (051073)

44/

1/2

ITF PROGRAM FILE

PROGRAM   Call Name RWM   GFC&C FILE 216AN

DESCRIPTION   This program is for analyzing Retaining Walls or Abutments on Pile Foundations. Computes (1) Moments and Forces caused by Substructure, Earth Pressure and Live Load Surcharge, (2) Footing Design and (3) Stem Design.

INPUT   For detailed information of input see Figures 1, 2, 3 and Sample Runs.

Retaining Wall and/or Abutment Input

1. Weight of Concrete and Backfill (kips/cu.ft.) and Equivalent Fluid Pressure (kips/sq.ft./ft.depth)

2. Pavement Thickness (Ft.)

3. Width and Thickness of Footing and Toe Length (Ft.)

4. Distance of 1st row of piles from the toe (Ft.)

5. Maximum Design Pile Load (kips)

6. Concrete allowable Flexure and Shear Stresses for Footing (ksi)

7. Allowable Steel Stress (ksi) and Ratio of Modulus of Elasticity for Footing.

8. Concrete cover to C_L of bottom steel and top steel.

9. Height of wall (Ft.)

10. Concrete allowable Flexure and Shear Stresses for Stem (ksi).

11. Allowable Steel Stress (ksi) and Ratio of Modulus of Elasticity for Stem.

12. Concrete cover to C_L Reinforcing Steel of Stem (in.)

13. Items "a" and "b" for Retaining Walls only.
    Items "c" thru "g" for Abutments only.

Retaining Walls only:

a. Parapet Height and Width (Ft.)

b. Stem Top Width (Ft.) and Rear Face Batter (N/12)

c. Soil Slope (n1/1), Slope Distance

Abutments Only:

d. Height and Width of Beam Seat (Ft.)

e. Height and Width of Backwall (Ft.)

f. Height and Width of Backwall Batter (Ft.)

g. Abutment Batter (N/12)

h. Distance from the Front Face of Wall to C_L of Bearing (Ft.)

14. Live Load Surcharge (Ft.)

15. Abutment Only

a. Dead Load and Live Load Reactions (kips/Ft.)

b. Additional Vertical and Horizontal Forces (kips/Ft.) applied at Bearing Support.

c. Group Factor

16. Number of Rows of Piles (Max. 4)

17. Distance (Ft. from 1st row) and Batter (N/12) of each Pile.

18. Pile Spacing of each Row (Ft.)

OUTPUT Moments and Forces caused by Substructure
Earth Pressure and Live Load Surcharge
Total Pile Area (Piles/Ft)
Vertical Pile Load
Total Pile Load
Horizontal Load Due to Batter
Horizontal Load taken by pile in Bending

For Footing Design (Heel and Toe)

Required Depth
Actual Depth
Required Steel

Shear Stress

For Stem Design

Wall Height
Compression Steel
Actual Depth
Required Steel (Tension)

Shear Stress

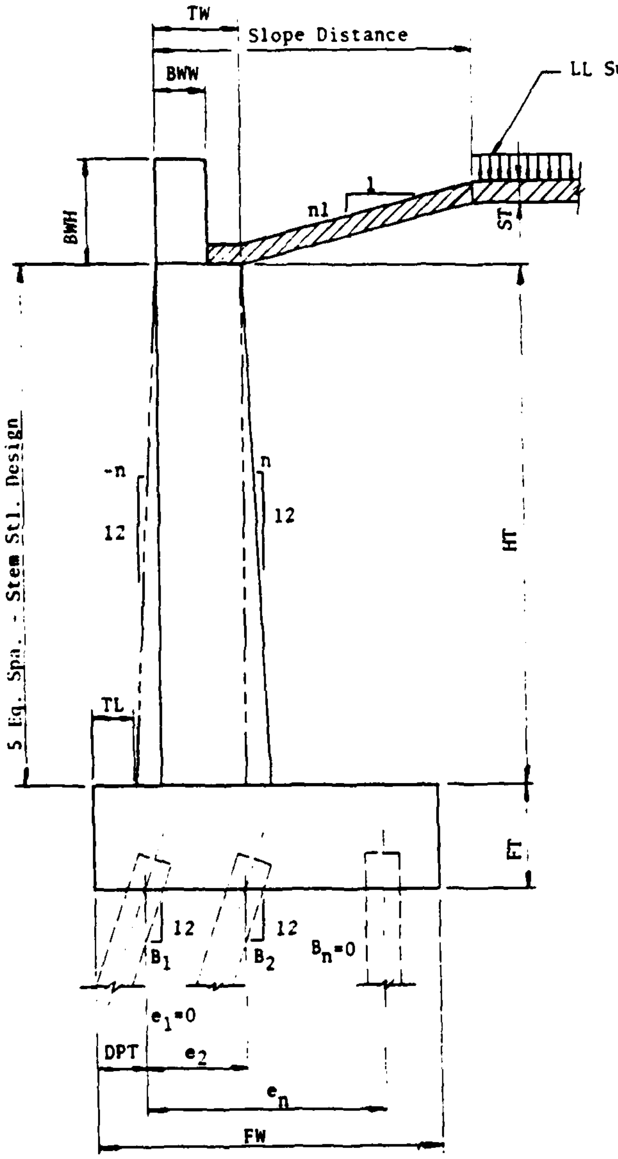
FEATURES

1. Pile configuration input may be repeated as many times as desired until the best design is obtained.

2. Size of footing may be changed following each pile analysis.

3. Batter may be input for the Front Face or the Rear Face - program will not handle both F.F. and R.F. Batter at the same time.

GEOMETRY OF RETAINING WALL



HT = height of wall
FW = width of footing
FT = depth of footing
TL = toe length
DPT = distance to 1st row of piles from the tip of toe
BWH = height of backwall
BWW = width of backwall
TW = top width of stem
n = batter of retaining wall
ST = pavement thickness
B_n = batter of nth row of piles
e_n = distance between nth row of piles and first row of piles
n_1 = surcharge slope

FIGURE 1. RETAINING WALL

GEOMETRY OF ABUTMENT

HT = height of wall
FW = width of footing
FT = depth of footing
DPT = distance to 1st row of piles from the tip of toe
ST = pavement thickness
BH = height of beam seat
BW = width of beam seat
BWW = width of backwall
BWH = height of backwall
BBH = height of backwall batter
BBW = width of backwall batter
n = batter of abutment
BFL = dist. from the F.F. of abutment to C.L. of bearing
TL = toe length
B_n = batter of nth row of piles
e_n = distance between first row of piles and nth row of piles

All the loadings are applied at Pt. A

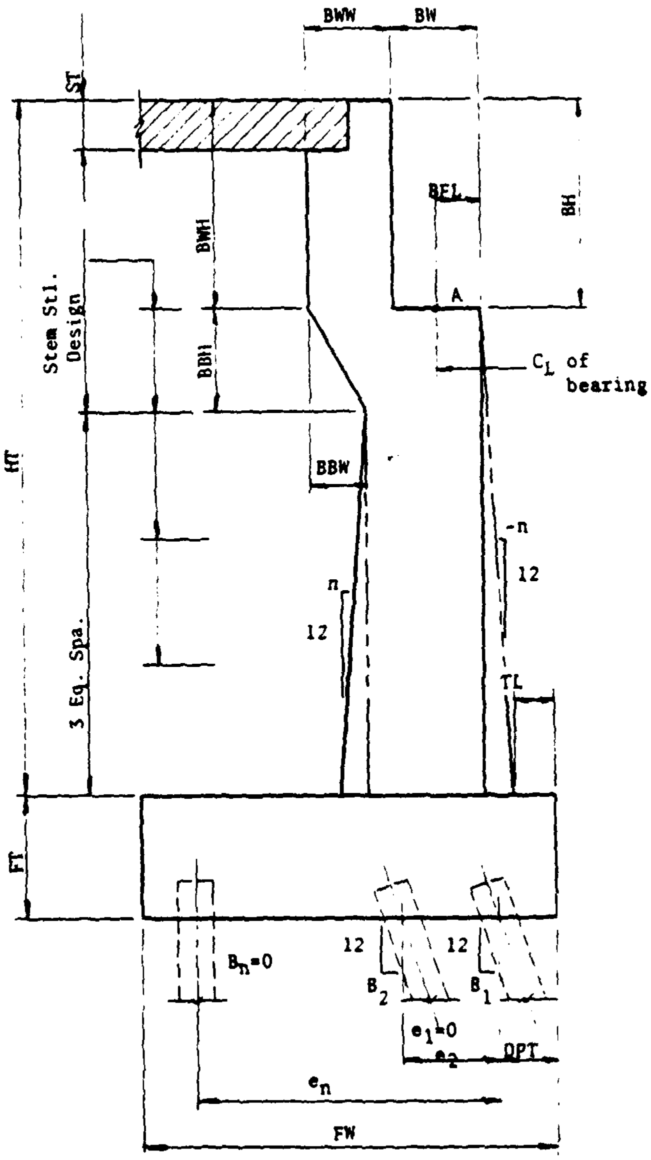


FIGURE 2. ABUTMENT

PILE ARRANGEMENT

PMA = pile capacity
n = No. of rows of piles
e_1 = 0.0
e_n = distance between nth row of piles and 1st row of piles
P_n = pile spacing of nth row of piles

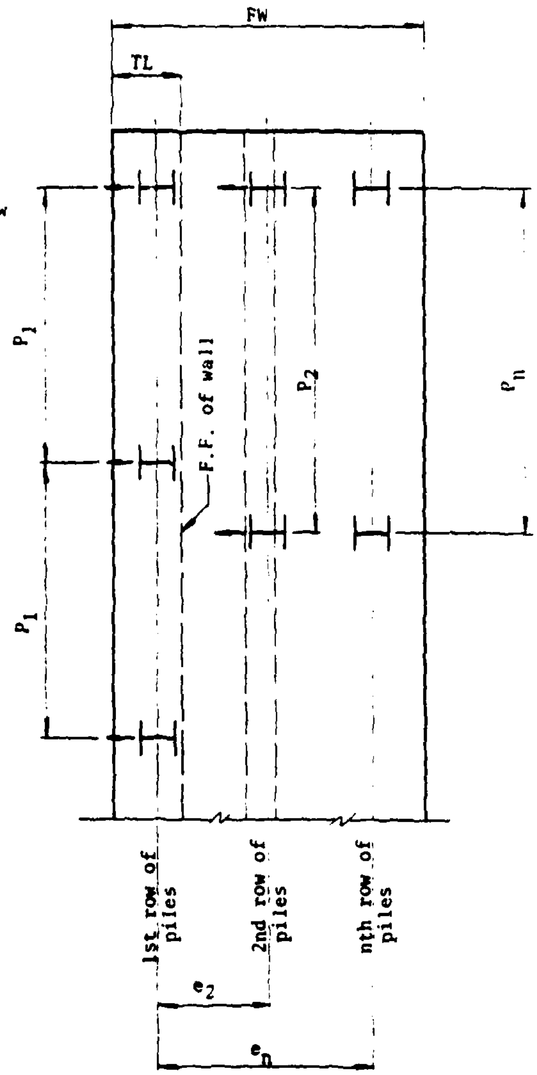


FIGURE 3. PILE ARRANGEMENT

ITF PROGRAM FILE

PROGRAM Call Name UCD GFC&C FILE 216AS

DESCRIPTION This program computes Load and Moment points for the interaction curve. Ø has not been included (ie Ø = 1.0). Points are based on increments to neutral axis location. The section must be rectangular and all reinf. bars are included. The first value is Po and the last is at P= 0. Finally, the balanced design case is output.

INPUT
W = Column width - In
T = Column thickness - In
FC = Concrete f'c - Ksi
FY = Reinf. fy - Ksi
N = No. of Reinf. Locations - (32 max.)
X = N.A. Increment - In
D_n = Dist. to Reinf. - In] 4 pair of values per line
A_n = A_s at each Dist. - In^2]

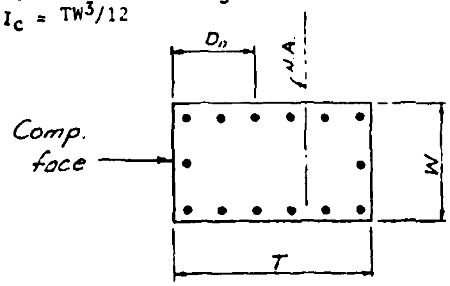
OUTPUT
All Input
I_c - ft^4 & I_s - ft^4
$E_cI_c/5+E_sI_s$ - $K\text{-}ft^2$
0.1 $f'cA_g$ - K & A_s/A_s -

Neutral Axis Location -	In	At P_o, each increment, P = 0 and lastly at Balanced Design
Axial Force -	K	
Moment -	K-ft	
Eccentricity -	Ft	

FEATURES The program conforms to 1974 AASHTO Interim Specifications. For ACI code applications, use Program ULT.

Note: *To plot 0.1 f'c Ag on this output where Ø = 1, divide* $0.1f'_c A_g$ by Ø = 0.7

$E_c = 57.00\sqrt{f'c}$ & $E_s = 29000$ ksi
$I_c = TW^3/12$



(121675) 1/2

BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

PHASE II
GENERAL DESIGN MEMORANDUM

APPENDIX D

DESIGN ANALYSIS

AUGUST 1979

SUBAPPENDIX D3

COMPUTATIONS FOR RIPRAP AND GABION DESIGN

SUBAPPENDIX D3

COMPUTATIONS FOR RIPRAP AND GABION DESIGN

CONTENTS

METHODOLOGY

y = depth of flow γ = UNIT WT WATER = 62.5 pcF

1. DETERMINE AVERAGE VELOCITY (V)
   = TOTAL DISCHARGE / TOTAL AREA (Q/A)

2. DETERMINE LEFT AND RIGHT CHANNEL SIDE SLOPES (S_L & S_R)

3. FROM EM-1110-2-1601 PAGE 36 AND PLATE 29, DETERMINE IF RIPRAP IS NEEDED

4. DETERMINE RADIUS OF CHANNEL ℄ (R)

5. DETERMINE TOPWIDTH (T) OF WATER SURFACE

6.* DETERMINE BEND FACTOR (BF)
   WHERE $BF = 3.1\left(T/R\right)^{0.5}$ (EM 1110-2-1601 PLATE 34)

7. DETERMINE NON UNIFORM FLOW FACTOR (NU)
   $NU = 1.5$ IF $BF < 1.5$ (ETL 1110-2-120 Pd4)
   $NU = BF$ IF $BF \geq 1.5$

8. ASSUME D_{50} (MIN)

8a DETERMINE LOCAL BOUNDARY SHEAR τ_o =

$$\gamma\left[\frac{V}{32.6\,\log_{10}\dfrac{30y}{D_{50\,min}}}\right]^2 \quad \text{(ETL 1110-2-120 Pd3)}$$

---

* Referring to Plate 34, EM 1110-2-1601, the curve "Rough Channel (Extrapolated)" is used. Where the abscissa value is 1.0 the ordinate value is 3.1 - which is the coeffient for the curve.

8819

9. DETERMINE DESIGN SHEAR τ = $\alpha(\gamma_s - \gamma)$ $D50_{MIN}$

α = 0.04 γ_s = DRY UNIT WT. OF STONE ASSUMED 155 pcF

10. MULTIPLY τ BY K_1 FOR REVISED DESIGN SHEAR (τ') WHERE K_1 =
$\left(1 - \frac{\sin^2\phi}{\sin^2\theta}\right)^{0.5}$ $\theta = 40°$
$\phi = \tan^{-1}\left(\frac{1}{S_L} \text{ or } \frac{1}{S_R}\right)$
EM 1110-2-1601 PLATE 36

11. DETERMINE RATIO (Z)
$\frac{\tau'}{\tau_0}$

12. IF Z = NU OK
IF NOT, CHANGE $D50_{MIN}$ AND GO TO 8

13. DETERMINE RIPRAP THICKNESS FROM $D50_{MIN}$
$D50$ USED ABOVE IS $D50$ MINIMUM IN FEET PER ETL 1110-2-120
$D50_{MAX}$ = 1.15 $D50_{MIN}$
(REF ETL 1110-2-120 INCL. 1)
T (RIPRAP THICKNESS) = 12 IN/FT × 1.5 × $D50_{MAX}$
(REF ETL 1110-2-120 INCL. 1)

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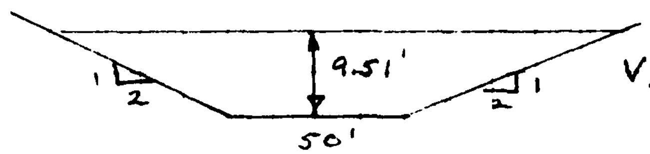
GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN FILE NO. 7622
SHEET NO. 3 OF 17 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY AHW DATE 1/23/79 CHECKED BY FFM DATE 2-23-79

DIVERSION CHANNEL

USED AS SAMPLE FOR TABLE
ON PAGES 6-8

STATION 8.00, COMPUTER = 67+72 D - DIVERSION CHANNEL



V_{AVG} = 10.66 FPS

K_1 (SIDE SLOPE FACTOR) = 0.718
TOPWIDTH = 88.04' R = ∞

BEND LOSS FACTOR = 1.00
NONUNIFORM FLOW FACTOR = 1.5
USE 1.5

FOR BOTTOM $K_1 = 1.00$

$\tau_0 = 0.761$ $D_{50} = 0.31'$

$\tau = 1.147$

$\tau \times K_1 = 1.147$

$\dfrac{\tau \times K_1}{\tau_0} = \dfrac{1.147}{0.761} = 1.51$

6.4" RIPRAP

FOR SIDES $K_1 = 0.718$

$\tau_0 = .879$ $D_{50} = 0.50$

$\tau = 1.85$

$\tau \times K_1 = 1.330$

$\dfrac{\tau \times K_1}{\tau_0} = \dfrac{1.33}{.879} = 1.51$

10.4" RIPRAP

USE 12" RIPRAP

8813

DIVERSION CHANNEL

LINE	STATION	LOCATION	COMPUTER PRINTOUT STATION	SL	SR	depth Y FT	VAVG FPS	RADIUS R FT
1	59+72D	SIDES	0.00	$\frac{2}{1}$	$\frac{2}{1}$	12.2	7.7[illegible]	R = 572.[illegible] STA. 61+05 D TO 62+22D
2		BOTTOM				"	"	
3	61+72D	SIDES	2.00	$\frac{2}{1}$	$\frac{2}{1}$	11.4	8.44	
4		BOTTOM				"	"	
5	63+72D	SIDES	4.00	$\frac{2}{1}$	$\frac{2}{1}$	10.67	9.20	
6		BOTTOM				"	"	
7	65+72D	SIDES	6.00	$\frac{2}{1}$	$\frac{2}{1}$	10.03	9.96	
8		BOTTOM				"	"	
9	67+72D	SIDES	8.00	$\frac{2}{1}$	$\frac{2}{1}$	9.51	10.66	CONCRETE STRUCTURE STARTS AT 67+72D
10		BOTTOM				"	"	

STA 10.00 (computer) = 69+72.20 (ALIGNMENT)

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GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN FILE NO. 7622
SHEET NO. 5 OF 17 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY [illegible] DATE 1/23/79 CHECKED BY FEM DATE 2-23-79

DIVERSION CHANNEL

LINE	K_1	T FT	BF	NU	COMMENTS
1	.718	98.8	1.28	1.5	VELOCITY GREATER THAN 6 FPS ∴ RIPRAP NEEDED
2	1.00	98.8	1.28	1.5	
3	.718	95.6	1.27	1.5	
4	1.00	95.6	1.27	1.5	
5	.718	92.67	1.25	1.5	
6	1.00	92.67	1.25	1.5	
7	.718	90.12	1.00	1.5	
8	1.00	90.12	1.00	1.5	
9	.718	88.04	1.00	1.5	
10	1.00	88.04	1.00	1.5	

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GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN FILE NO. 7622
SHEET NO. 6 OF 17 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY [illegible] DATE 1/23/79 CHECKED BY FFM DATE 2-23-79

DIVERSION CHANNEL

LINE	D_{50} FT	τ_o PSF	τ PSF	τ' PSF	K	DESIGN RIPRAP THICKNESS	SELECTED RIPRAP THICKNESS
1	.19	.324	.702	.505	1.56	3.9"	12"
2	.12	.288	.444	.444	1.54	2.5"	12"
3	.24	.421	.888	.638	1.51	5.0"	12"
4	.16	.378	.592	.592	1.57	3.3"	12"
5	.31	.548	1.147	.824	1.50	6.4"	12"
6	.20	.485	0.74	0.74	1.53	4.1"	12"
7	.40	.705	1.48	1.063	1.51	8.3"	12"
8	.25	.615	.925	.925	1.50	5.2"	12"
9	.50	.879	1.85	1.33	1.51	10.4"	12"
10	.31	.761	1.147	1.147	1.51	6.4"	12"

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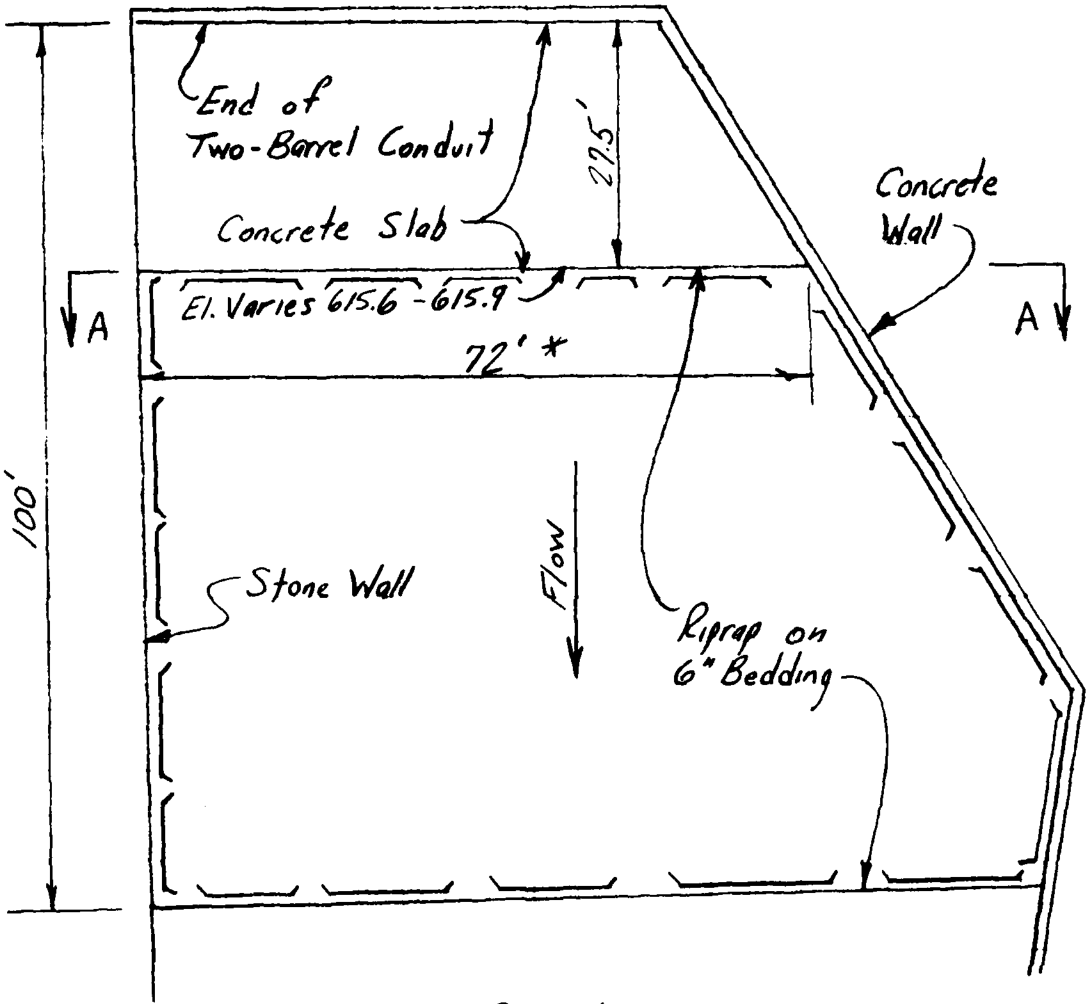
GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN FILE NO. 7622
SHEET NO. 7 OF 17 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY [signature] DATE 1/23/79 CHECKED BY FFM DATE 2-23-79

END OF TWO-BARREL CONDUIT



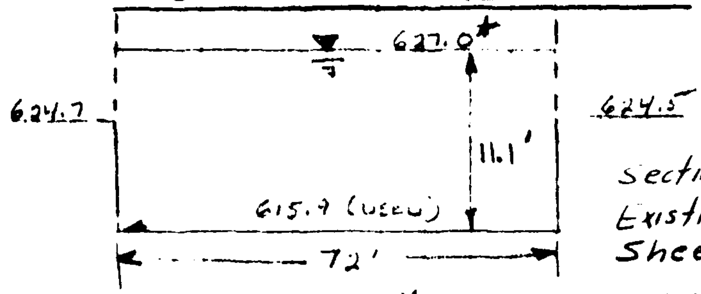
PLAN

CHANNEL AT END OF TWO-BARREL CONDUIT

* Dimension from survey notes.

8818

END OF TWO-BARREL CONDUIT



Q = 6,000 cfs

Section at End of Existing Slab, Section A-A, Sheet 7 of 17.

*From plate 15, Phase I GDM

$A = 72 \times 11.1 = 799.2$

$V = Q/A = 7.51$ fps

$D_{50} = .12$

$\tau_0 = .280$

$\tau = \tau' = .444$

$\frac{\tau_0}{\tau'} = z = 1.59$

Riprap size = 2.5"
Use 12"

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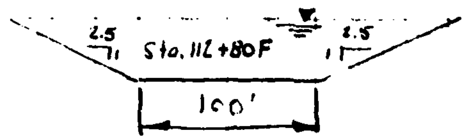
GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN FILE NO. 7622
SHEET NO. 9 OF 17 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY aww DATE 1/23/79 CHECKED BY FFM DATE 2-23-79

DOWNSTREAM END OF CHUTE - TRANSITION



NOTE: Riprap NEED per PHASE I GDM

	SIDES	BOTTOM
S_L	2.5	—
S_R	2.5	—
Y	8.11	8.11
V_{AVG}	6.16	6.16
R	∞	∞
K_1	.816	1.00
T	140.55	140.55
BF	1.00	1.10
NU	1.5	1.5
D_{50}	.10'	.08'
τ_0	.195	.184
τ	.37	.296
τ'	.30	.296
Z	1.55	1.61
DESIGN THICKNESS	2.1"	1.7"
SELECTED THICKNESS	12"	12"

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STATION	91+60F		95+00F		100+00F		125+00F		110+00F	
	SIDE	BOT	SIDE	BOT	SIDE	BOT	SIDE	BOT	SIDE	BOT
S_L	2.5	—	2.5	—	2.5	—	2.5	—	2.5	—
S_R	2.5	—	2.5	—	2.5	—	2.5	—	2.5	—
Y	8.42		6.44		6.46		5.91		5.67	
V_{AVG}	9.37		13.09		13.05		12.74		12.58	
R	—		—		818.5		—		716.2	
K_1	.816	—	.816	—	.816	—	.816	—	.816	—
T	N/A		N/A		87.3		N/A		98.34	
BF	1.0		1.0		1.01		1.0		1.15	
NU	1.5		1.5		1.5		1.5		1.5	
D_{50}	.30	.23	.94	.68	.93	.68	.91	.66	.89	.65
τ_0	.603	.558	1.884	1.674	1.863	1.662	1.821	1.617	1.788	1.592
τ	1.11	.851	3.478	2.516	3.441	2.516	3.367	2.442	3.293	2.405
τ'	.906	.851	2.838	2.516	2.808	2.516	2.747	2.442	2.687	2.405
Ξ	1.50	1.52	1.51	1.50	1.51	1.51	1.51	1.51	1.50	1.51
DESIGN THICK	6.2"	4.8"	19.5"	14.1"	19.3"	14.1"	18.8"	13.7"	18.4"	13.5"
SELECTED THICK	← 12" GABION = 24" RIPRAP →									
	No. 5		No. 4		No. 3		No. 2		No. 1	

DROP STRUCTURES

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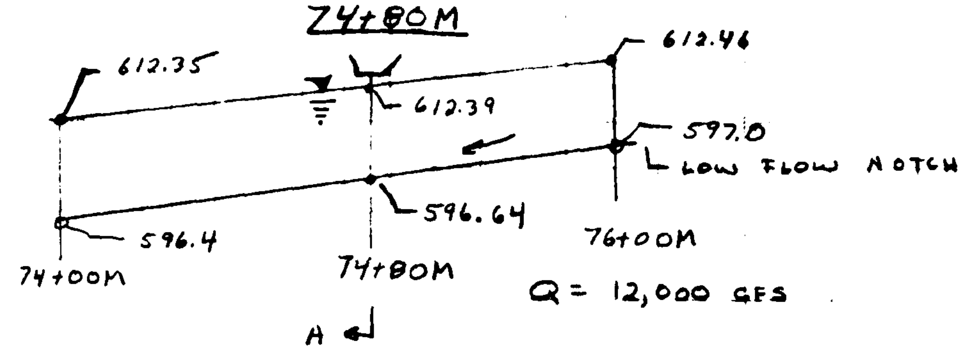
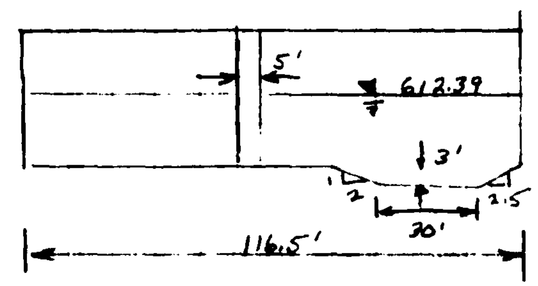
GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT: RIPRAP AND GABION DESIGN   FILE NO. 7622
SHEET NO. 11 OF 17 SHEETS
FOR: BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY: AHW   DATE: 1/25/79   CHECKED BY: FFM   DATE: 2-23-79

RAILROAD SPURLINE BRIDGE



Q = 12,000 CFS



$$A = (116.5-5) \times (612.39 - 596.64 - 3) + 3\,(30 + 2.25 \times 3) = 1531.88$$

$$V = \frac{12{,}000}{1531.88} = 7.83 \qquad y = 612.39 - 596.64 = 15.75$$

$D_{50} = 0.12'$
$\tau_o = .279$ 2.5" RIPRAP USE 12"
$\tau = \tau' = 0.444$ (FLAT BOTTOM)
$\tau_o/\tau' = 1.69$

(FLAT BOTTOM)
$D_{50} = 0.15$ 3.1" RIPRAP USE 12"
$\tau_o = .295$ (1V ON 2.5H SLOPES)
$\tau = 0.535$
$\tau' = 0.453$
$\tau_o/\tau' = 1.54$

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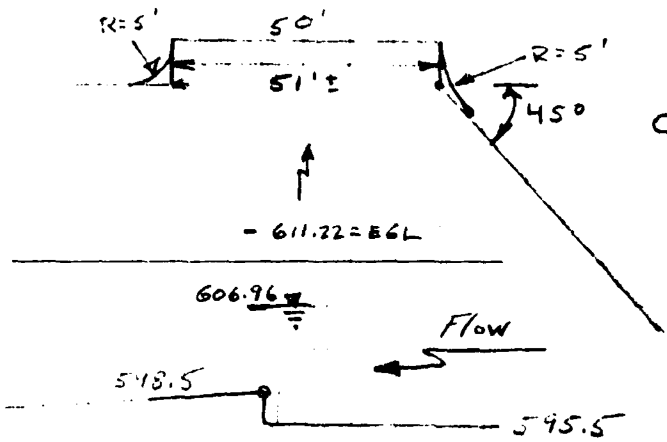
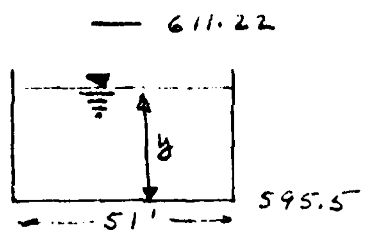
APPROACH TO DIVERSION CHANNEL FLUME



Q = 7,000 CFS

USING EGL AND ASSUMING NO LOSSES



$$y + \frac{Q^2}{2g \cdot 51^2 y^2} = 611.22 - 595.5 = 15.72$$

$$y + \frac{7000^2}{64.36 \times 51^2 \times y^2} = 15.72$$

$y = 14.29'$

$A = 728.79 \qquad V = Q/A = 9.60$ fps

FOR 1V ON 2.5H SIDE SLOPES

$D_{50} = 0.27'$

$\tau_0 = 0.529 \qquad$ 5.6" OF RIPRAP

$\tau = 0.999 \qquad$ USE 12" RIPRAP

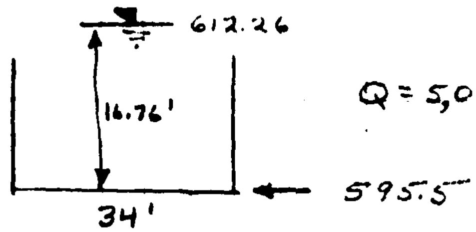
$\tau' = 0.815$

$\tau_0/\tau' = 1.54$

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN FILE NO. 7622
SHEET NO. 13 OF 17 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY AHJ DATE 1/25/79 CHECKED BY FFM DATE 2-23-79

NEW B & O RAILROAD BRIDGE



Q = 5,000 CFS

A = 569.84 □'
V = 8.77'

FOR 1V ON 2.5H SLOPE

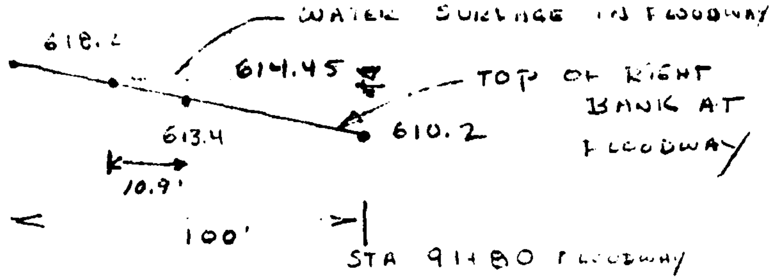
D_{50} = .20'
τ_0 = .391 — 4.6" RIPRAP
τ = 0.74 — USE 12" RIPRAP
τ' = .60
τ_0/τ' = 1.54

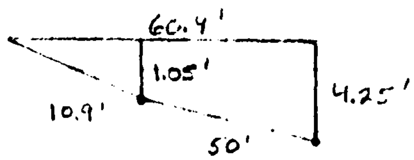
8819

END OF THREE-BARREL CONDUIT AND CONFLUENCE AREA

— EGL = 614.98

FOR FLOW OVER NOSE





$A = 1.05 \times 10.9/2 + \left(\frac{1.05 + 4.25}{2}\right) \times 50 = 138.22$

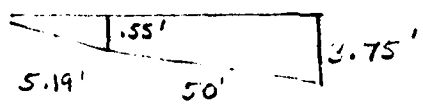
$T = 60.9'$

$Q = \sqrt{\frac{A^3 g}{T}} = 1181.3$

$V_{AVG} = 8.5$ FPS $\quad h_v = 1.13'$

THIS IS EXCESSIVE EGL > AVAILABLE ENERGY

drop 0.5'



$A = 108.92$

$T = 55.19$

$Q = 868 \approx 870$ CFS

$V = 7.97$ FPS $\quad h_v = 0.99'$

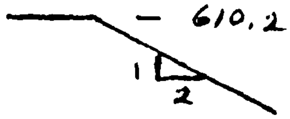
EGL = 614.93 OK

6813

END OF THREE-BARREL CONDUIT AND CONFLUENCE AREA

EGL = 614.93

FOR FLOW OVER NOSE



$H = 4.73$

$HV = \frac{1}{3} H$ (AT CRITICAL DEPTH)

$= 1.57'$

$V = \sqrt{1.57 \times 64.36} = 10.07'$

$d = \frac{2}{3} HV = 3.14'$

FOR 1V ON 2H SLOPE

$D_{50} = 0.78'$

$\tau_o = 1.376$ — 16.1" RIPRAP

$\tau = 2.886$ — 18" Riprap Required

$\tau' = 2.072$ — However, 12" Gabions Selected

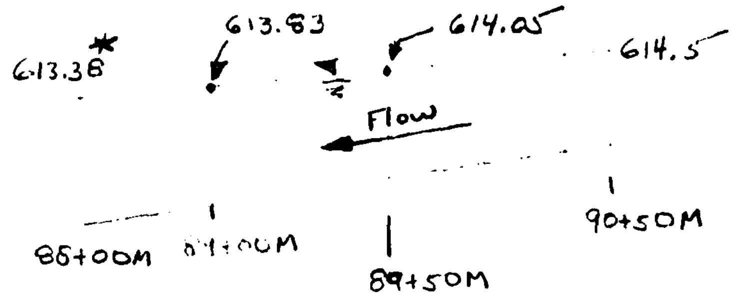
$\tau_o/\tau_1 = 1.51$

8819

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

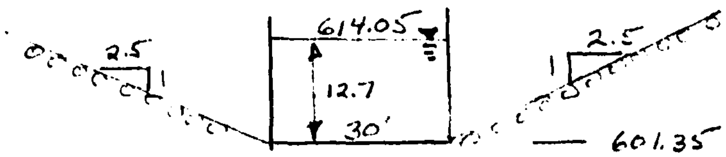
SUBJECT: RIPRAP AND GABION DESIGN — FILE NO. 7622
SHEET NO. 16 OF 17 SHEETS
FOR: BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY: A Hur — DATE: 1/26/79 — CHECKED BY: FFM — DATE: 2-23-79

END OF THREE-BARREL CONDUIT AND CONFLUENCE AREA



* From Phase I GDM

Q = 6,000 cfs



89+50M

A = 12.7 × 30 = 381 □'

V = $\frac{6000}{381}$ = 15.74 fps

1V on 2.5H slope (.816)

D_{50} = 1.14'

τ_o = 2.287

τ = 4.218

τ' = 3.442

τ_o/τ' = 1.50

Riprap = 23.6"

24" Riprap Required

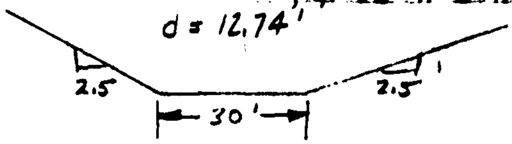
Use Equivalent 12" Gabions

6919

END OF THREE-BARREL CONDUIT AND CONFLUENCE AREA

STA. 89+00M

W.S. El. 613.83, Grade El. 601.08
d = 12.74'



$A = 12.74(30 + 2.5 \times 12.74) = 787.97$

$T = 2.5 \times 2 \times 12.74 + 30 = 93.72$

$V = Q/A = 7.61$

$R = 301.55'$

$3.1 \left(\frac{T}{R}\right)^{0.5} = 1.728 > 1.5$ USE 1.728

$D_{50} = .19$

$\tau_0 = .312$

$\tau = .703$

$\tau' = .574$

$\tau_0/\tau' = 1.838$

Riprap = 3.9"

USE = 12"

MODIFIED TO 24" RIPRAP (12" GABIONS) because OF VERY UNCERTAIN FLOW CONDITIONS

8919

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN FILE NO.
SHEET NO. 17a OF SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY [illegible] DATE 7/30/79 CHECKED BY [illegible] DATE 7/30/79

IN APPENDIX A, "SOILS AND GEOLOGY REPORT", A RIPRAP AND bedding MATERIAL GRADATION IS GIVEN. AFTER APPENDIX A WAS PREPARED, IT WAS determined THAT MOST OF THE STONE AVAILABLE HAD A UNIT WEIGHT OF 10 pcf LESS, OR 155 pcf. REVISED GRADATIONS FOR RIPRAP AND bedding ARE GIVEN below:

STONE FOR 12-INCH RIPRAP THICKNESS

Percent Lighter by Weight	Stone Weight in Pounds*
100	81(12.0")
62-100	32(8.8")
50- 72	24(8.0")
30- 50	16(7.0")
15- 38	12(6.3")
0- 15	5(4.7")

STONE FOR 18-INCH RIPRAP THICKNESS

Percent Lighter by Weight	Stone Weight in Pounds*
100	274(18.0")
62-100	110(13.3")
50- 72	81(12.0")
30- 50	55(10.5")
15- 38	41(9.6")
0- 15	17(7.1")

*Numbers in parentheses are approximate stone diameters in inches corresponding to the weights given, assuming a spherical shape and a unit weight of 155 pounds per cubic foot.

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BEDDING MATERIAL

Sieve Size (U.S. Standard)	Percent Passing by Dry Weight
3"	100
2"	85-100
1 1/2"	78--90
3/4"	68--78
1/2"	60--73
No. 4	43--60
No.10	26--43
No.20	12--26
No.40	0--12
No.200	0--03

CRITERIA FROM EM 1110-2-1901, "SOIL MECHANICS DESIGN, SEEPAGE CONTROL" STATE THAT

$$\frac{D_{15}\ \text{RIPRAP}}{D_{15}\ \text{BEDDING}} > 5 \quad \text{(PERMEABILITY)}$$

$$\frac{D_{15}\ \text{RIPRAP}}{D_{85}\ \text{bedding}} < 5 \quad \text{(piping PREVENTION)}$$

The FOLLOWING, FROM THE GRADATIONS, APPLY

	MIN	MAX
D_{15} 18" RIPRAP	7.1"	9.6"
D_{15} 12" RIPRAP	4.7"	6.3"
D_{15} bedding	.02"	.04"
D_{85} bedding	1.18"	1.97"

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN FILE NO. ____
SHEET NO. 12C OF ____ SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY AHW DATE 7/30/79 CHECKED BY DJW DATE 7/30/79

THE CRITICAL RELATIONSHIP FOR PERMEABILITY USES D_{15} RIPRAP MIN AND D_{15} bedding MAX, WHILE FOR PIPING PREVENTION D_{15} RIPRAP MAX AND D_{15} bedding MIN ARE USED

	12" RIPRAP	18" RIPRAP	CRITERIA
$\frac{D_{15} \text{ RIPRAP MIN}}{D_{15} \text{ bedding MAX}}$	$\frac{4.7''}{.04''} = 117.5$	$\frac{7.1''}{.04''} = 177.5$	>5
$\frac{D_{15} \text{ RIPRAP MAX}}{D_{85} \text{ bedding MIN}}$	$\frac{6.3''}{1.18''} = 5.3$ *	$\frac{9.6''}{1.18''} = 8.1$ **	<5

* NOT deemed A SIGNIFICANT deviation

** NOT WITHIN CRITERIA; HOWEVER, TO develop PIPING THROUGH RIPRAP, IT IS NECESSARY TO HAVE A HEAD differential, SUCH THAT FLOW OCCURS FROM THE GROUNDWATER THROUGH THE bedding AND RIPRAP. The only 18" RIPRAP AT THE SITE IS AT THE downstream END OF THE DIVERSION CHANNEL, WHERE SUCH HEAD DIFFERENTIALS WILL NOT EXIST. THEREFORE, FOR ECONOMY, ONLY ONE bedding MATERIAL IS SELECTED for USE ON THE PROJECT.

8815

BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

PHASE II
GENERAL DESIGN MEMORANDUM

APPENDIX D

DESIGN ANALYSIS

AUGUST 1979

SUBAPPENDIX D4

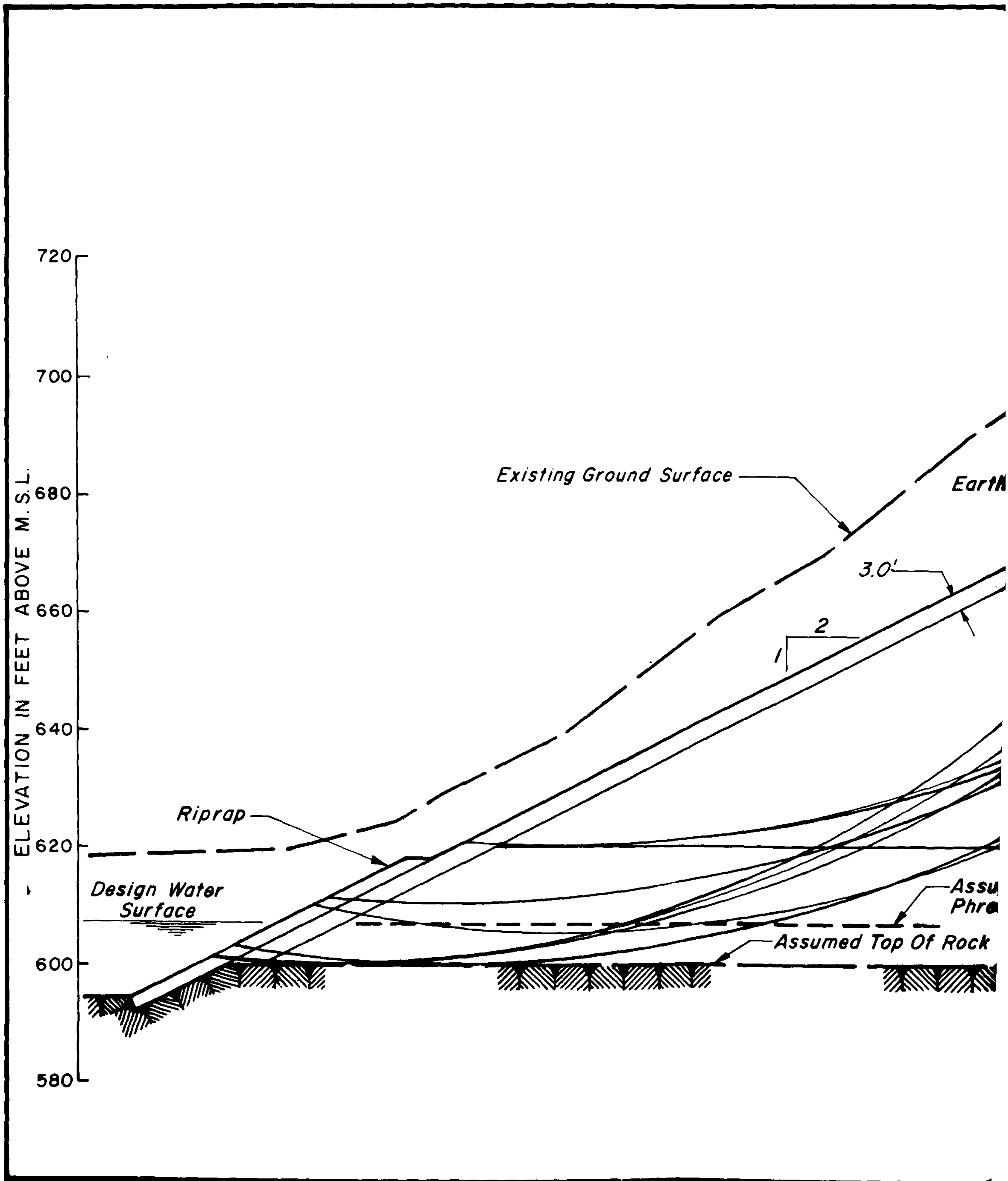
COMPUTER SOLUTION AND MANUAL CHECK
FOR
SLOPE STABILITY ANALYSES

SUBAPPENDIX D4

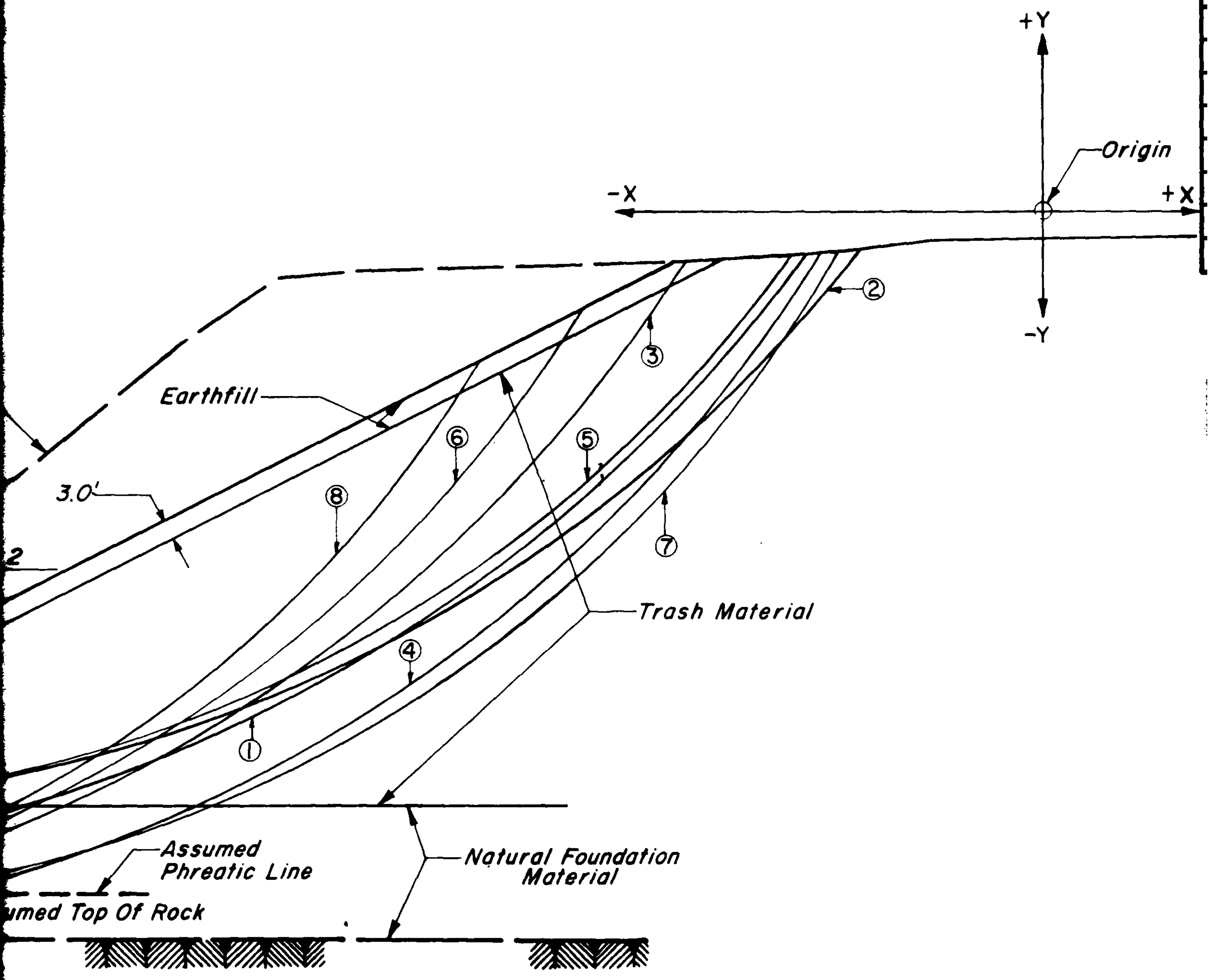
COMPUTER SOLUTION AND MANUAL CHECK FOR SLOPE STABILITY ANALYSES

CONTENTS

PLATES

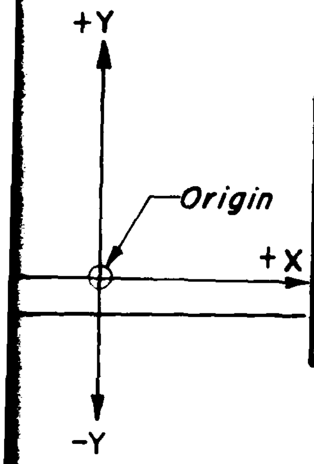


ELEVATION IN FEET ABOVE M.S.L.
720
700
680
660
640
620
600
580
Existing Ground Surface
3.0'
2
1
Riprap
Design Water Surface
Assumed Top Of Rock



STA. 64+00 D

SCALE: 1 IN. = 20 FT.



RESULTS					
ARC NO.	RADIUS	CENTER COORDINATES		FACTOR OF SAFETY	
		X	Y	SUDDEN DRAWDOWN	END OF CONSTRUCTION
1	230.0	-220.0	130.0	1.38	1.34
2	220.0	-200.0	130.0	1.53	1.37
3	220.0	-240.0	110.0	1.28 *	1.28
4	220.0	-220.0	110.0	1.34	1.17 *
5	200.0	-200.0	110.0	1.49	1.33
6	200.0	-240.0	90.0	1.29	1.32
7	195.0	-200.0	90.0	1.39	1.20
8	180.0	-240.0	70.0	1.29	1.39

* Critical Arc

BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

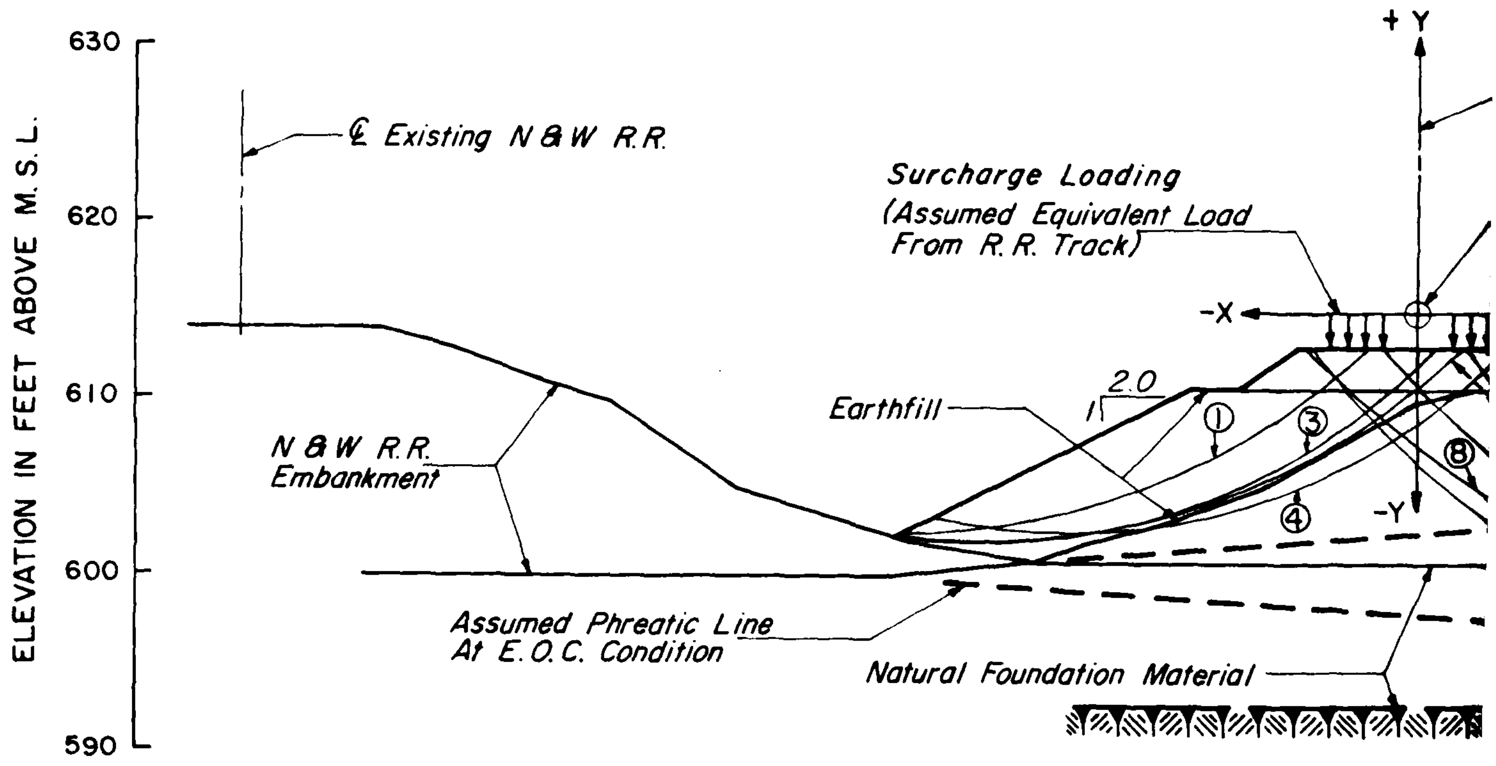
SUMMARY OF SLOPE STABILITY ANALYSIS RIGHT BANK-DIVERSION CHANNEL STA. 64+00 D

U. S. ARMY ENGINEER DISTRICT, BUFFALO
PHASE II GENERAL DESIGN MEMORANDUM

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
CONSULTING ENGINEERS
HARRISBURG, PENNSYLVANIA

MARCH 1979

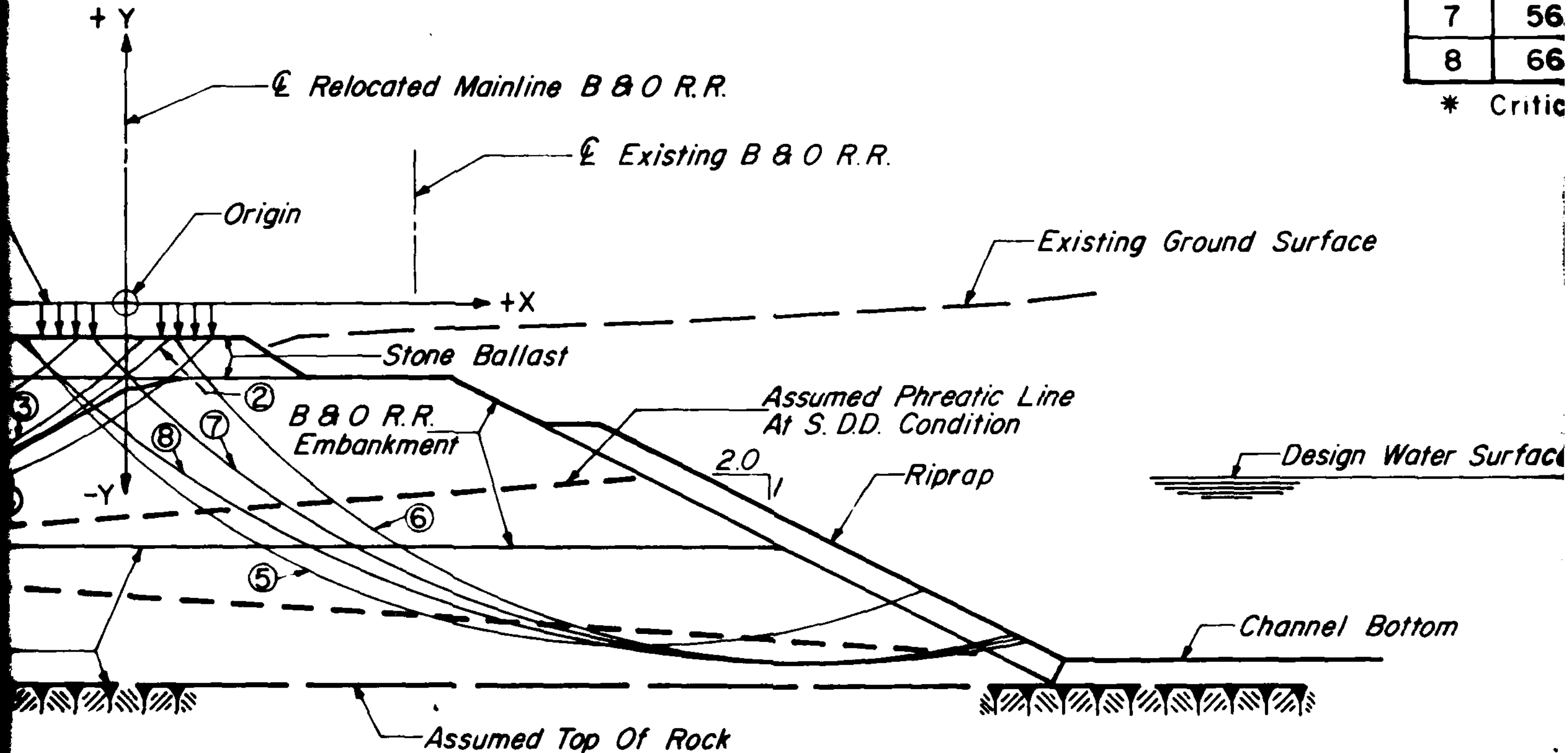
PLATE NO. D4-1



ELEVATION IN FEET ABOVE M.S.L.
630
620
610
600
590
℄ Existing N & W R.R.
Surcharge Loading
(Assumed Equivalent Load
From R.R. Track)
+Y
-X
-Y
2.0
1
Earthfill
N & W R.R.
Embankment
Assumed Phreatic Line
At E.O.C. Condition
Natural Foundation Material

ARC NO.	RAD
1	40
2	40
3	36.
4	35
5	45
6	46
7	56.
8	66

* Critic



STA. 64+00D

SCALE: 1 IN. = 10 FT.

RESULTS					
ARC NO.	RADIUS	CENTER COORDINATES		FACTOR OF SAFETY	
		X	Y	SUDDEN DRAWDOWN	END OF CONSTRUCTION
1	40.0	-30.0	27.5	2.11	8.58
2	40.0	-25.0	27.5	1.76 *	5.86
3	36.0	-25.0	22.5	1.84	4.81
4	35.0	-20.0	22.5	2.25	4.44
5	45.0	30.0	25.0	2.36	4.88
6	46.0	40.0	25.0	2.71	3.94
7	56.0	40.0	35.0	2.31	3.85
8	66.0	40.0	45.0	2.42	3.69 *

* Critical Arc

rface

sign Water Surface

nel Bottom

E. O. C. = End Of Construction
S. D. D. = Sudden Drawdown

BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

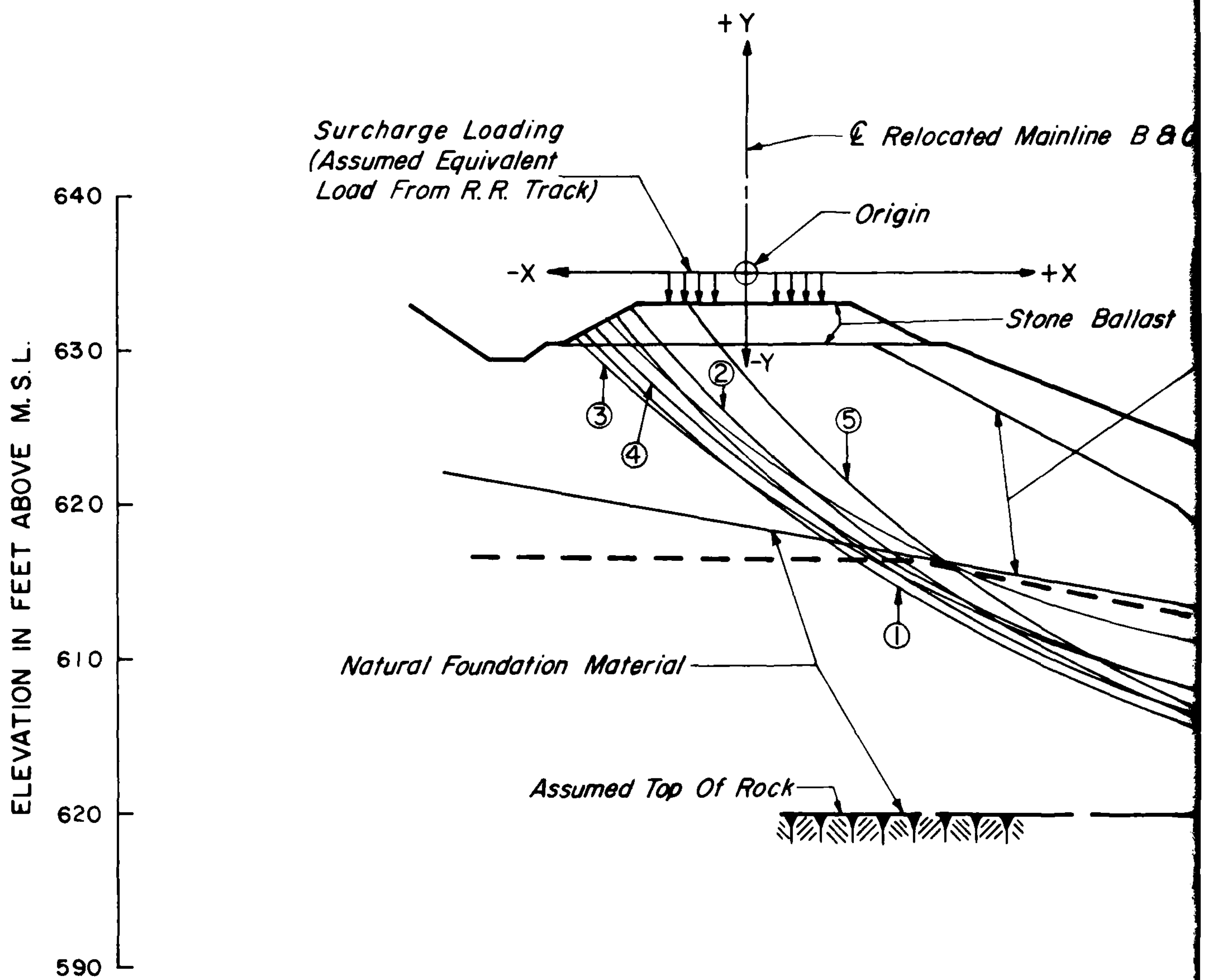
SUMMARY OF SLOPE STABILITY ANALYSIS LEFT BANK-DIVERSION CHANNEL STA. 64+00D

U. S. ARMY ENGINEER DISTRICT, BUFFALO
PHASE II GENERAL DESIGN MEMORANDUM

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
CONSULTING ENGINEERS
HARRISBURG, PENNSYLVANIA

MARCH 1979

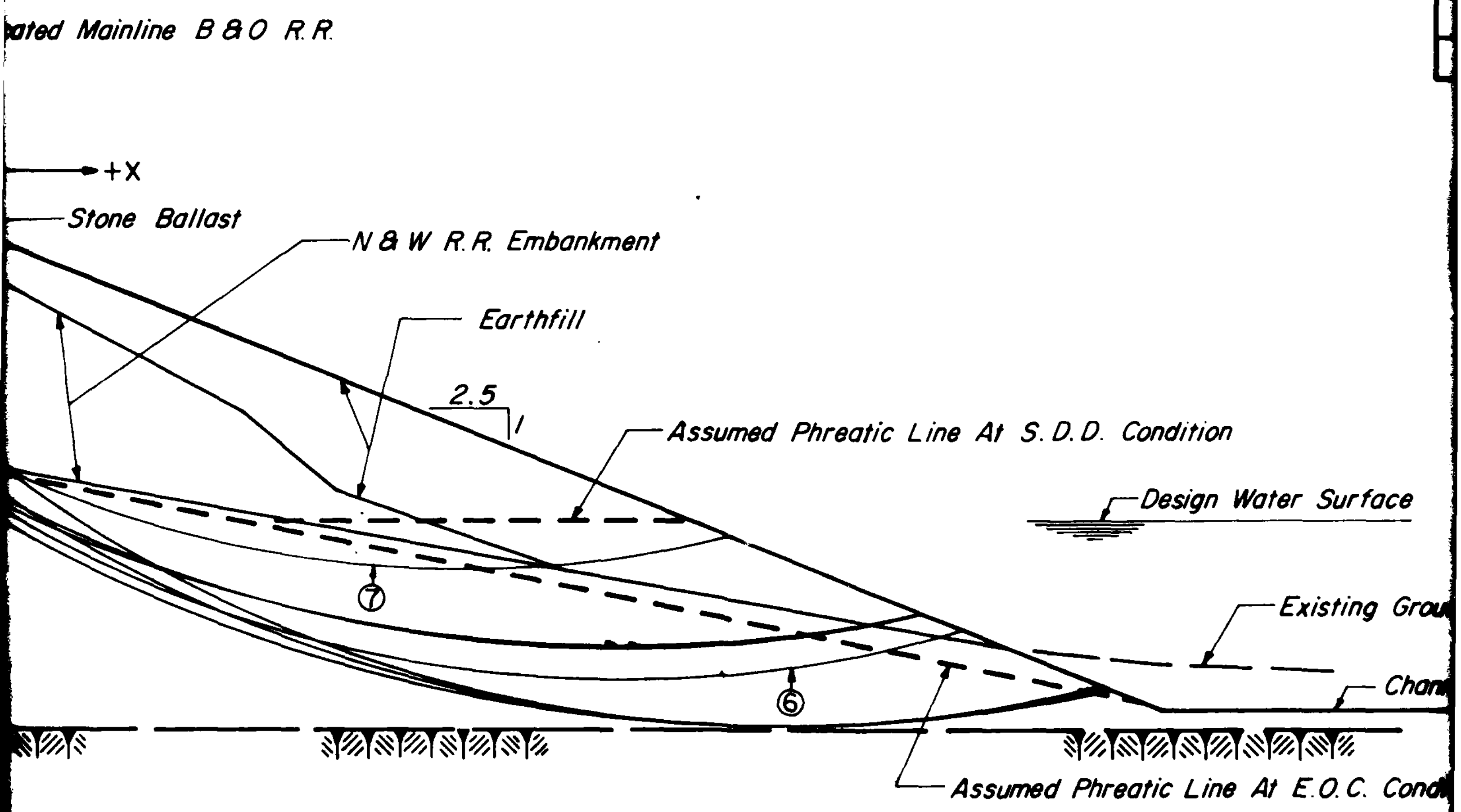
PLATE NO. D4-2



+Y
Surcharge Loading
(Assumed Equivalent
Load From R.R. Track)
℄ Relocated Mainline B & O
Origin
-X
+X
-Y
Stone Ballast
640
630
620
610
620
590
ELEVATION IN FEET ABOVE M.S.L.
②
③
④
⑤
①
Natural Foundation Material
Assumed Top Of Rock

STA. 8

SCALE 1

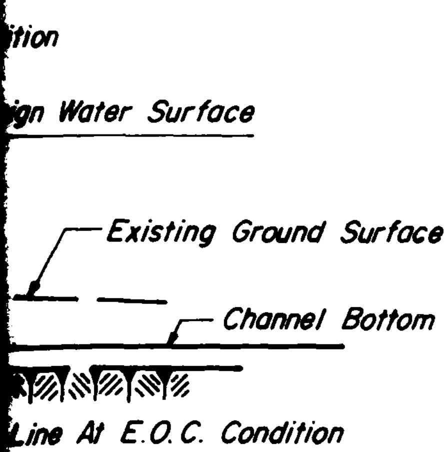


STA. 80 + 00 M

SCALE 1 IN. = 10 FT.

RESULTS					
ARC NO.	RADIUS	CENTER COORDINATES		FACTOR OF SAFETY	
		X	Y	SUDDEN DRAWDOWN	END OF CONSTRUCTION
1	100.0	62.0	65.0	1.70	2.57
2	90.0	62.0	55.0	1.64 *	2.32 *
3	90.0	52.0	60.0	1.99	2.98
4	85.0	52.0	55.0	1.89	2.85
5	82.0	62.0	47.0	1.69	2.49
6	77.0	52.0	45.0	1.74	2.59
7	70.0	42.0	45.0	1.93	3.21

* Critical Arc



BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

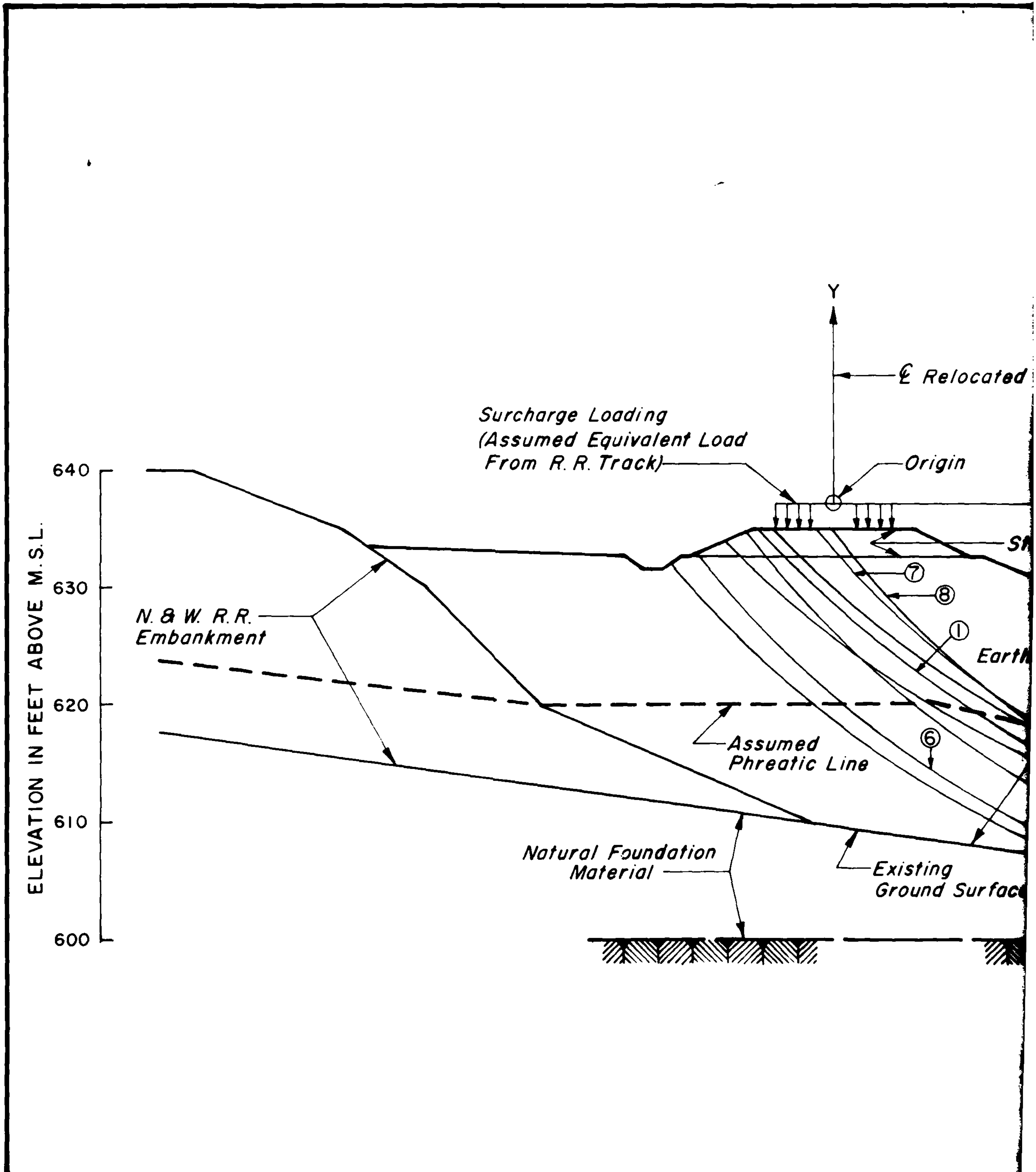
SUMMARY OF
SLOPE STABILITY ANALYSIS
LEFT BANK-MODIFIED CHANNEL
STA. 80+00M

U. S. ARMY ENGINEER DISTRICT, BUFFALO
PHASE II GENERAL DESIGN MEMORANDUM

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
CONSULTING ENGINEERS
HARRISBURG, PENNSYLVANIA

MARCH 1979

PLATE NO. D4-3

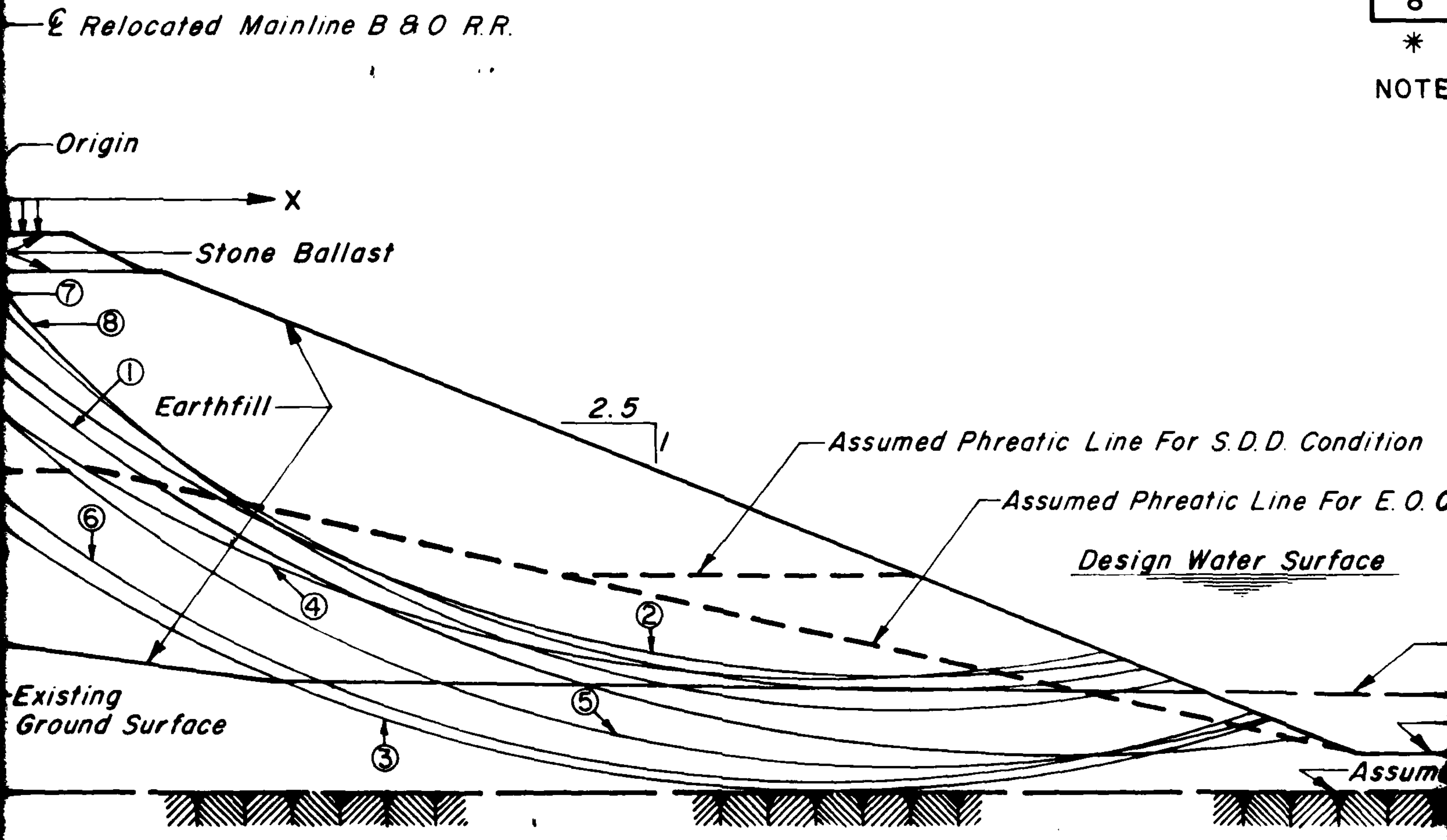


Y
℄ Relocated
Surcharge Loading
(Assumed Equivalent Load
From R. R. Track)
Origin
640
630
620
610
600
ELEVATION IN FEET ABOVE M.S.L.
N. & W. R.R.
Embankment
7
8
1
6
Earth
Assumed
Phreatic Line
Natural Foundation
Material
Existing
Ground Surfac

ARC NO.
1
2
3
4
5
6
7
8

*

NOTE



STA. 89 +50 F

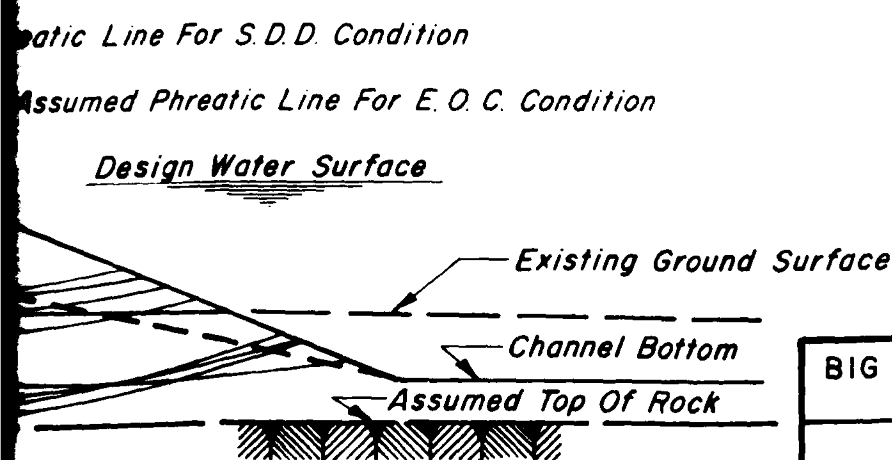
SCALE: 1 IN. = 10 FT.

2

RESULTS					
ARC NO.	RADIUS	CENTER COORDINATES		FACTOR OF SAFETY	
		X	Y	SUDDEN DRAWDOWN	END OF CONSTRUCTION
1	105.0	70.0	70.0	1.61	2.85
2	90.0	60.0	60.0	1.50 *	3.49
3	90.0	55.0	53.0	1.66	2.52 *
4	90.0	55.0	60.0	1.61	3.18
5	85.0	60.0	49.0	1.60	2.67
6	85.0	55.0	48.0	1.57	2.58
7	80.0	60.0	49.0	1.58	3.46
8	75.0	60.0	43.0	1.57	3.27

* Critical Arc

NOTE: Arc No. 2 was run by manual check, see Plate D4-8 and D4-9.



BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

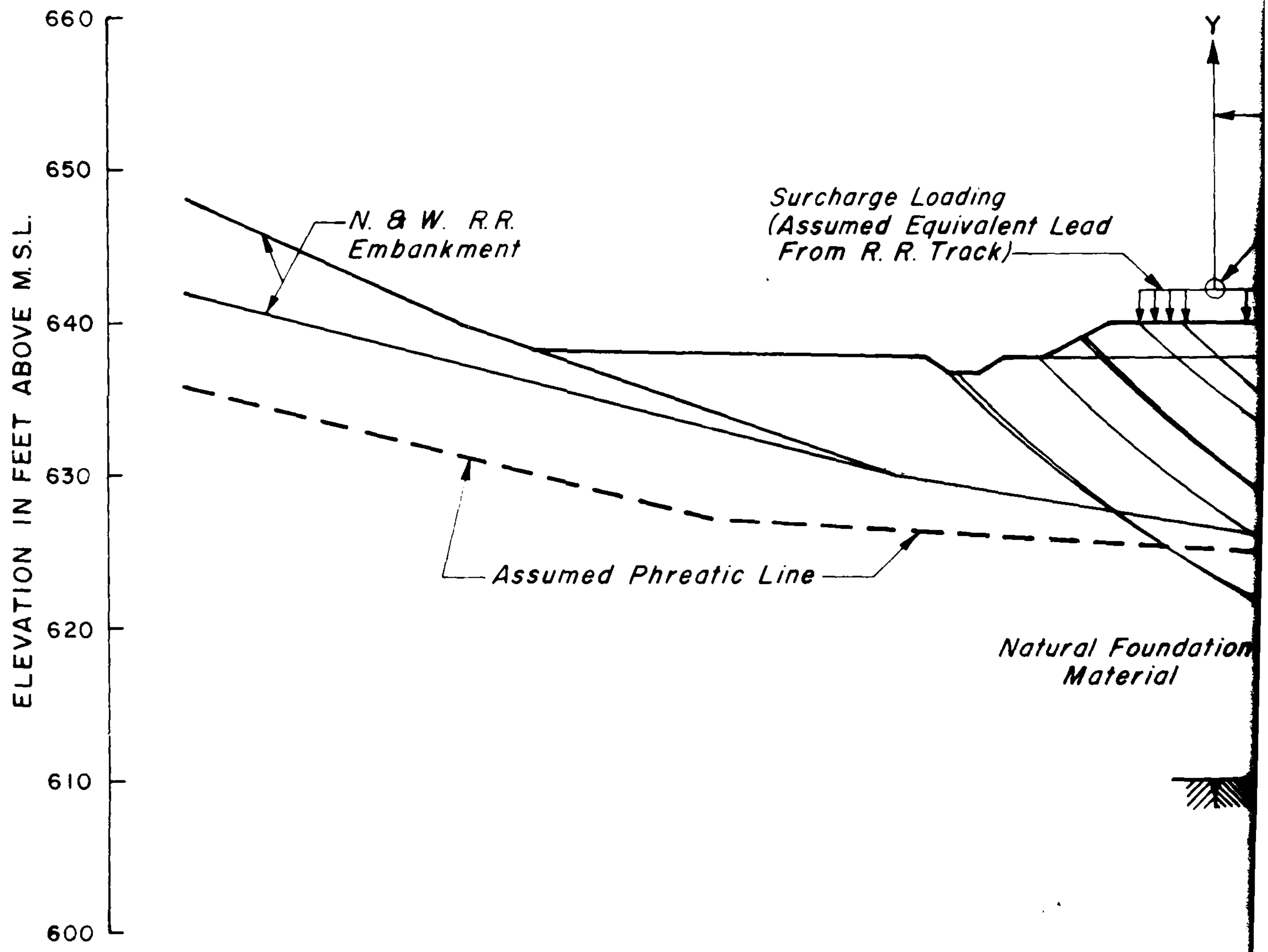
SUMMARY OF
SLOPE STABILITY ANALYSIS
LEFT BANK-FLOODWAY CHANNEL
STA. 89+50F

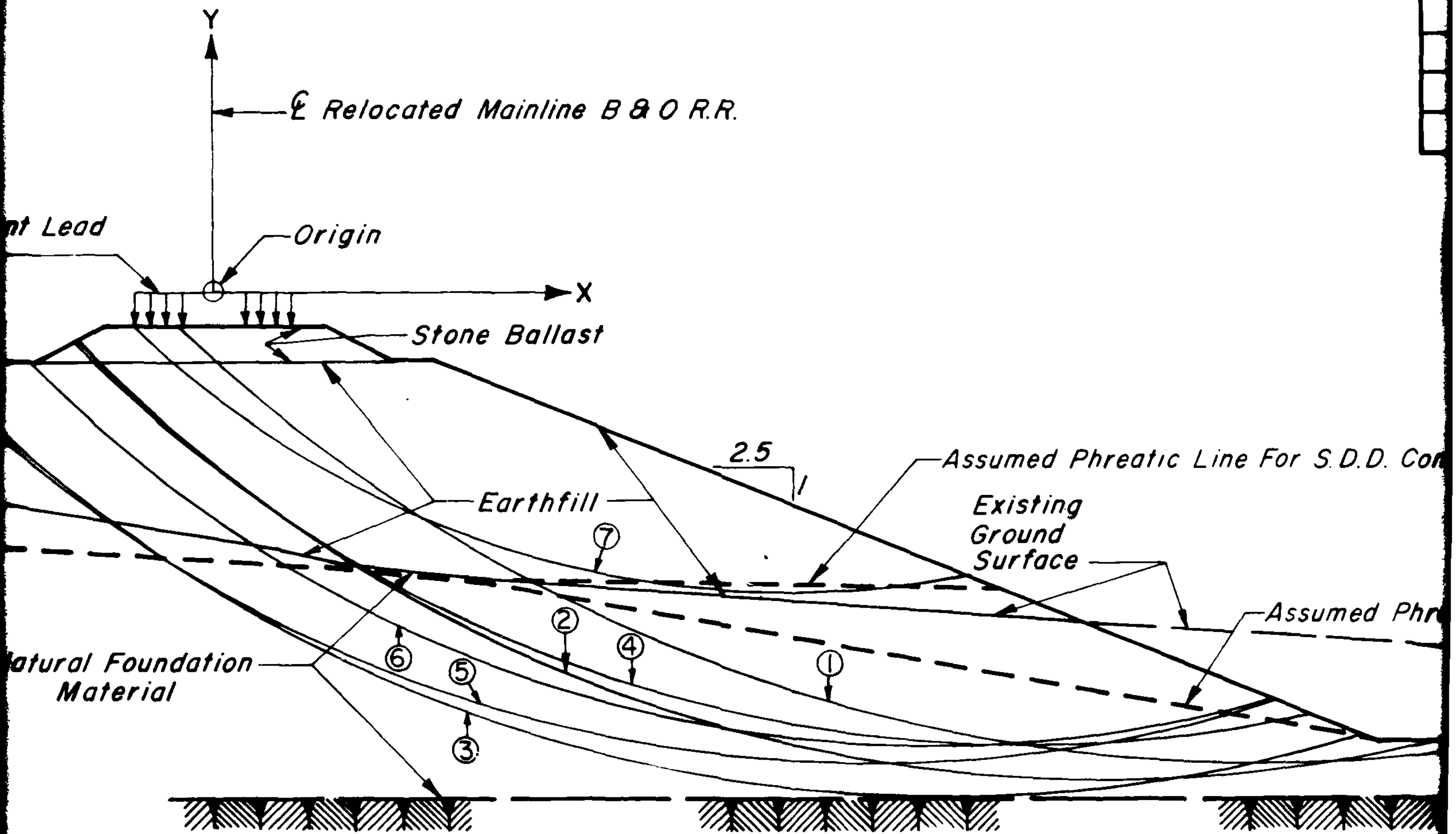
U. S. ARMY ENGINEER DISTRICT, BUFFALO
PHASE II GENERAL DESIGN MEMORANDUM

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
CONSULTING ENGINEERS
HARRISBURG, PENNSYLVANIA

MARCH 1979

PLATE NO. D4-4


ELEVATION IN FEET ABOVE M.S.L.
660
650
640
630
620
610
600
Y
N. & W. R.R.
Embankment
Surcharge Loading
(Assumed Equivalent Lead
From R. R. Track)
Assumed Phreatic Line
Natural Foundation
Material

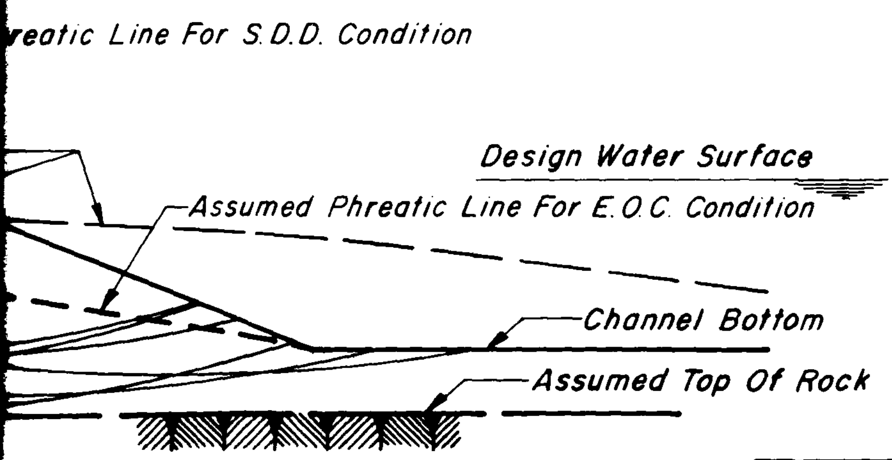


STA. 102 + 00 F

SCALE: 1 IN. = 10 FT.

RESULTS					
ARC NO.	RADIUS	CENTER COORDINATES		FACTOR OF SAFETY	
		X	Y	SUDDEN DRAWDOWN	END OF CONSTRUCTION
1	100.0	67.0	70.0	2.11	3.82
2	91.0	57.0	60.0	1.87	2.99
3	90.0	47.0	58.0	2.06	2.73
4	85.0	52.0	56.0	1.86	3.08
5	85.0	42.0	55.0	2.21	3.45
6	80.0	47.0	51.0	1.99	2.80 *
7	60.0	37.0	41.0	1.78 *	4.05

* Critical Arc



BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

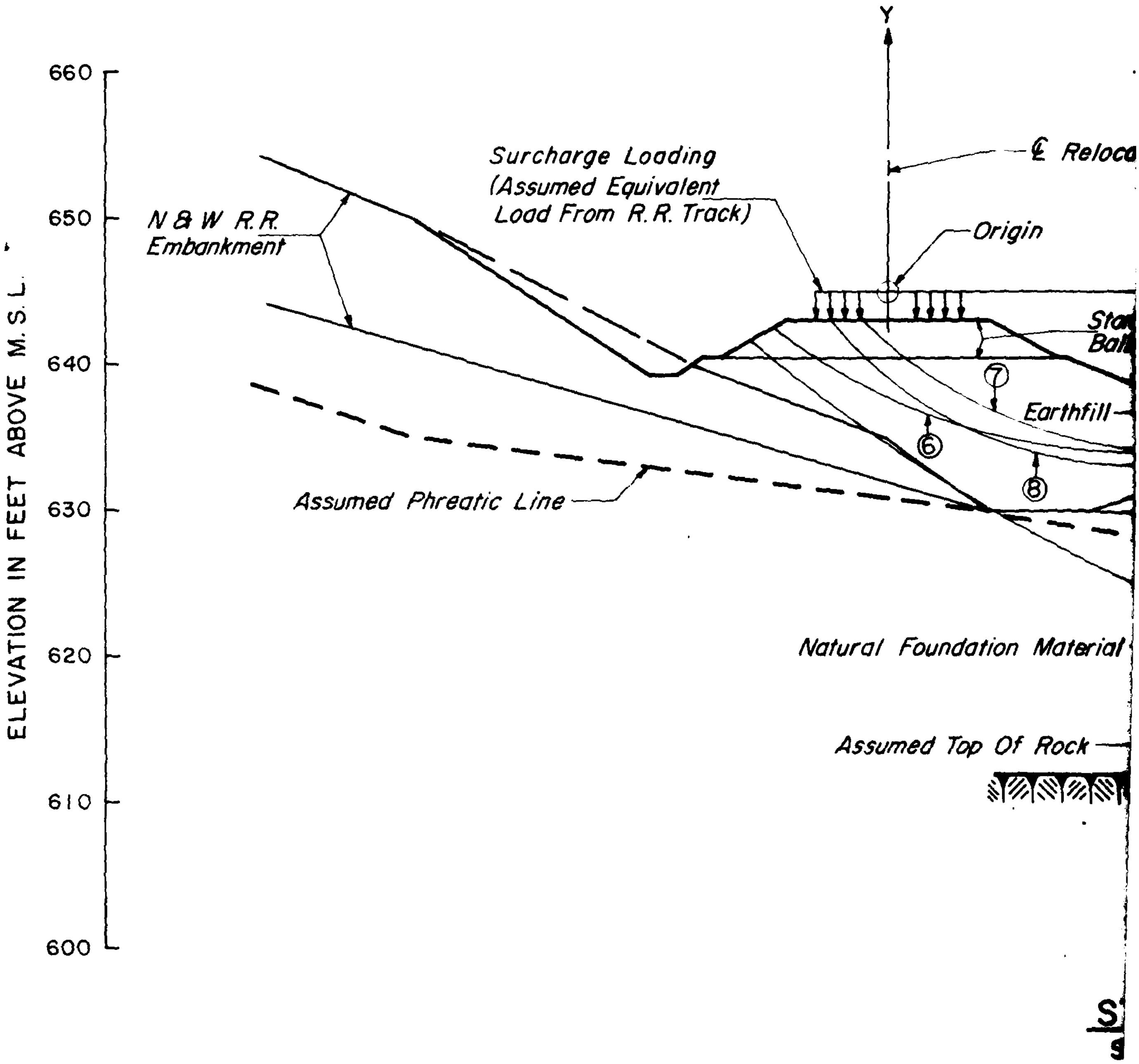
SUMMARY OF
SLOPE STABILITY ANALYSIS
LEFT BANK-FLOODWAY CHANNEL
STA. 102+00F

U. S. ARMY ENGINEER DISTRICT, BUFFALO
PHASE II GENERAL DESIGN MEMORANDUM

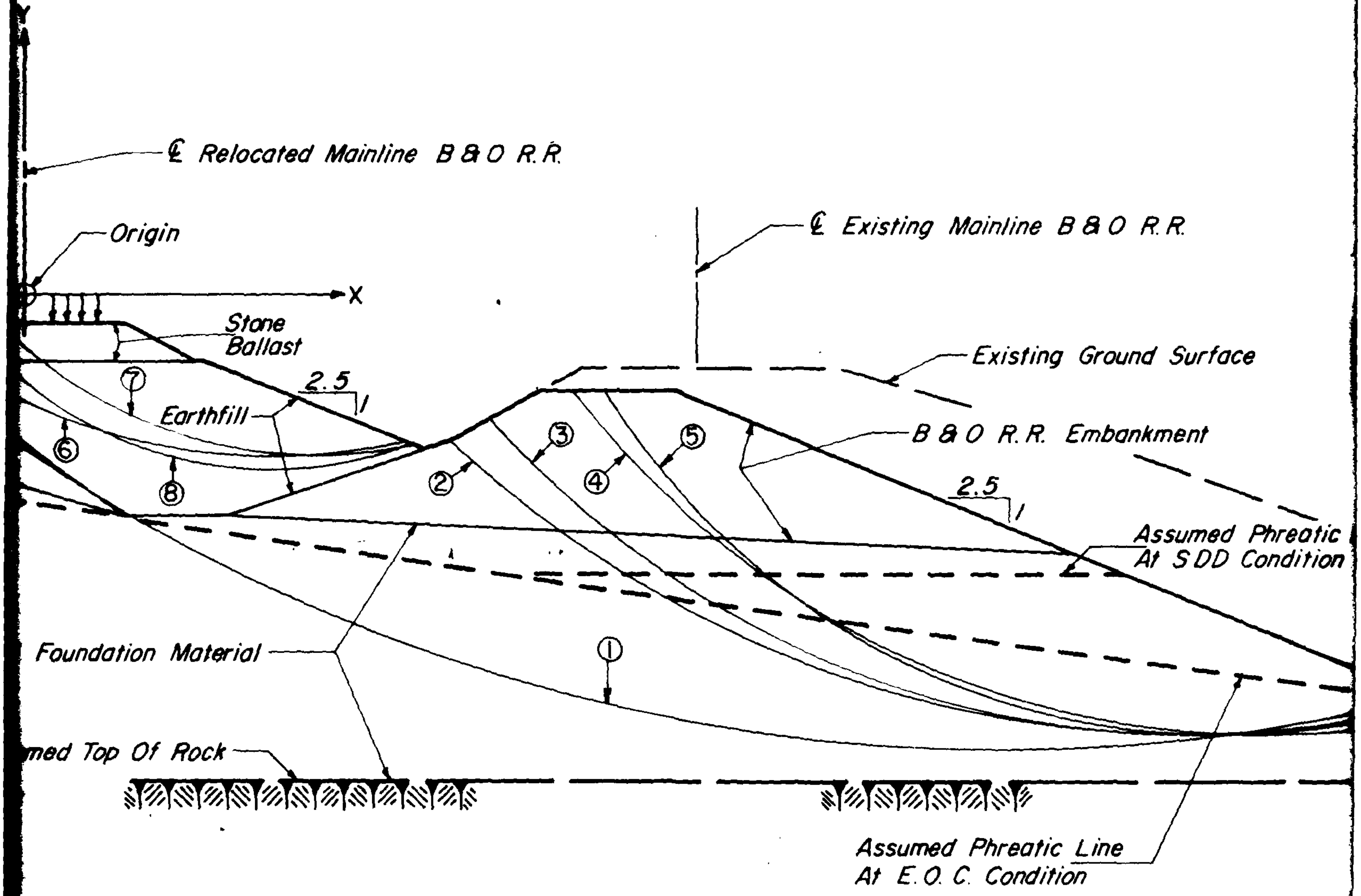
GANNETT FLEMING CORDDRY AND CARPENTER, INC.
CONSULTING ENGINEERS
HARRISBURG, PENNSYLVANIA

MARCH 1979

PLATE NO. D4-5



660
650
640
630
620
610
600
ELEVATION IN FEET ABOVE M. S. L.
N & W R.R. Embankment
Surcharge Loading (Assumed Equivalent Load From R.R. Track)
Y
℄ Reloca
Origin
Earthfill
6
7
8
Assumed Phreatic Line
Natural Foundation Material
Assumed Top Of Rock

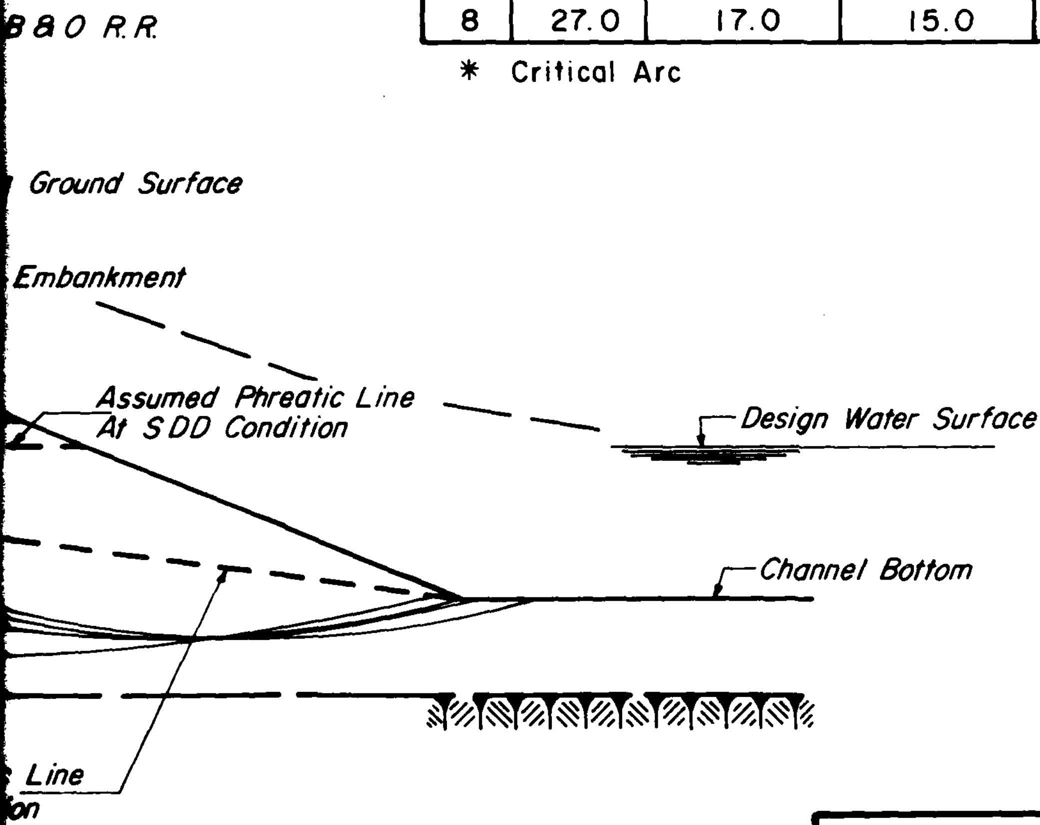


STA. 108+25F

SCALE: 1 IN. = 10 FT.

RESULTS					
ARC NO.	RADIUS	CENTER COORDINATES		FACTOR OF SAFETY	
		X	Y	SUDDEN DRAWDOWN	END OF CONSTRUCTION
1	120.0	67.0	89.0	2.67	3.71 *
2	75.0	80.0	45.0	3.00	4.12
3	65.0	80.0	35.0	2.98	4.08
4	60.0	85.0	30.0	2.90	5.00
5	50.0	82.0	20.0	2.79	4.80
6	41.0	17.0	30.0	2.57	6.10
7	31.0	20.0	20.0	2.27	5.71
8	27.0	17.0	15.0	2.21 *	5.65

* Critical Arc



BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

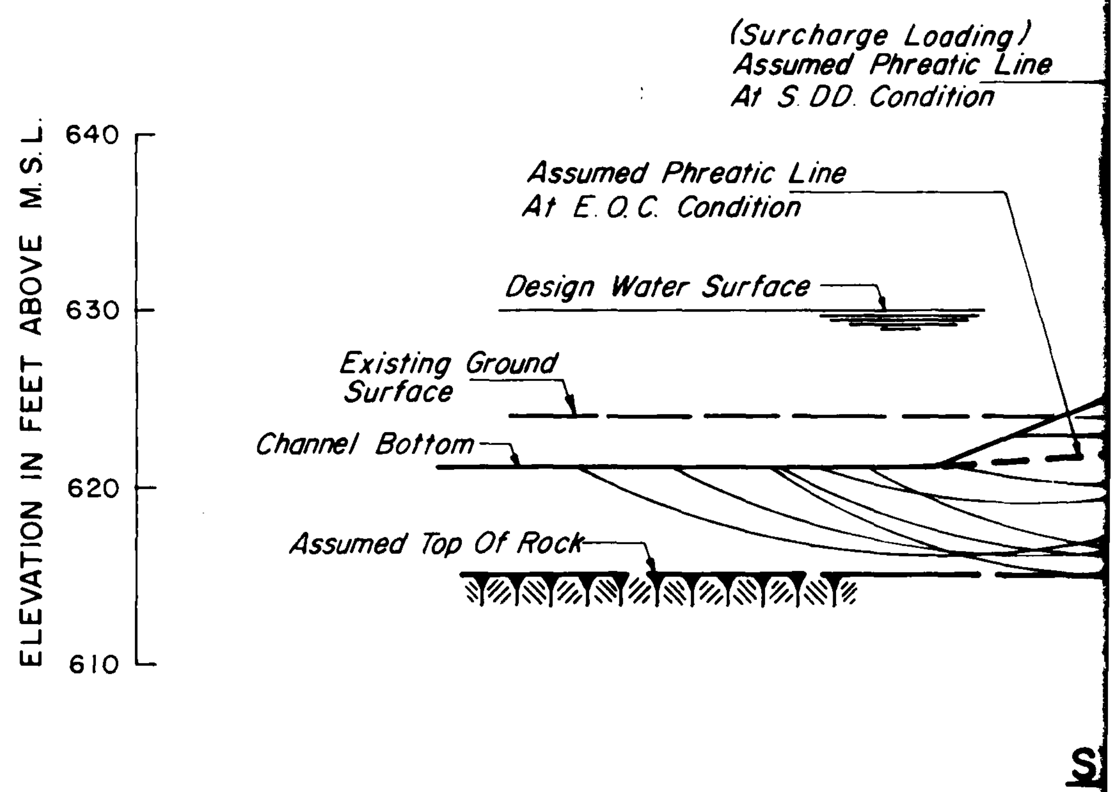
SUMMARY OF SLOPE STABILITY ANALYSIS LEFT BANK-FLOODWAY CHANNEL STA. 108+25F

U. S. ARMY ENGINEER DISTRICT, BUFFALO
PHASE II GENERAL DESIGN MEMORANDUM

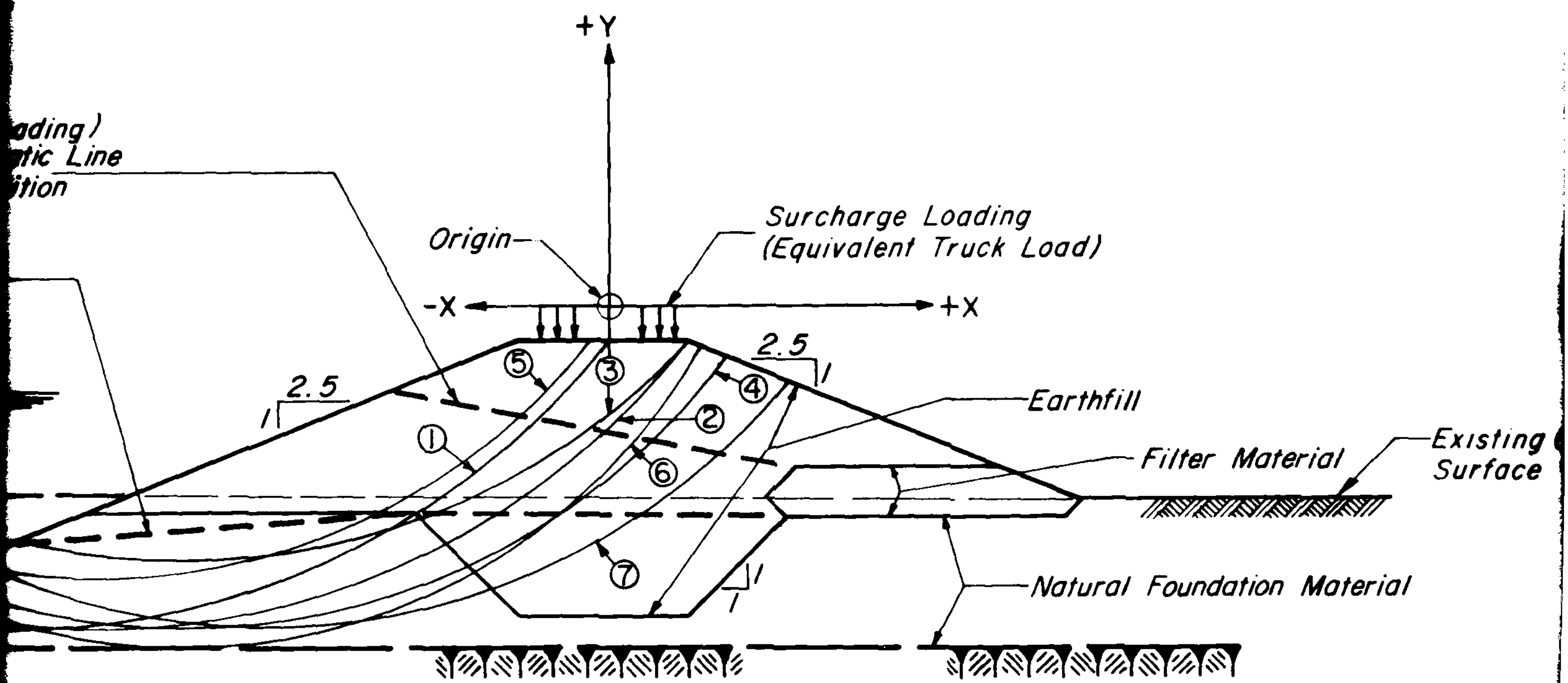
GANNETT FLEMING CORDDRY AND CARPENTER, INC.
CONSULTING ENGINEERS
HARRISBURG, PENNSYLVANIA

MARCH 1979

PLATE NO. D4-6



(Surcharge Loading)
Assumed Phreatic Line
At S. DD. Condition
Assumed Phreatic Line
At E. O. C. Condition
Design Water Surface
Existing Ground
Surface
Channel Bottom
Assumed Top Of Rock
ELEVATION IN FEET ABOVE M.S.L.
640
630
620
610

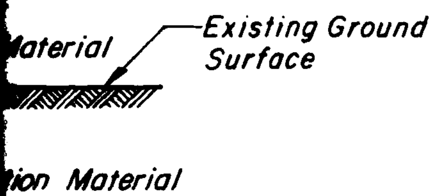


STA. 111 + 00F

SCALE 1 IN. = 10 FT.

RESULTS					
ARC NO.	RADIUS	CENTER COORDINATES		FACTOR OF SAFETY	
		X	Y	SUDDEN DRAWDOWN	END OF CONSTRUCTION
1	45.0	-35.0	26.0	3.69	7.12
2	44.0	-30.0	25.0	3.31	6.30 *
3	41.0	-25.0	26.0	2.58 *	6.79
4	40.0	-25.0	21.0	2.81	6.57
5	37.0	-30.0	21.0	3.50	7.67
6	35.0	-25.0	15.0	3.06	6.60
7	40.0	-20.0	21.0	3.22	7.33

* Critical Arc



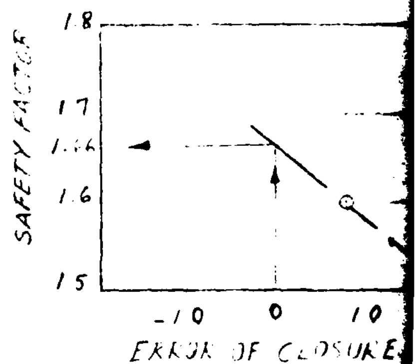
BIG CREEK FLOOD CONTROL PROJECT CLEVELAND, OHIO	
SUMMARY OF SLOPE STABILITY ANALYSIS LEVEE-FLOODWAY CHANNEL STA. 111+00F	
U. S. ARMY ENGINEER DISTRICT, BUFFALO PHASE II GENERAL DESIGN MEMORANDUM	
GANNETT FLEMING CORDDRY AND CARPENTER, INC. CONSULTING ENGINEERS HARRISBURG, PENNSYLVANIA	MARCH 1979
	PLATE NO. D4-7

3

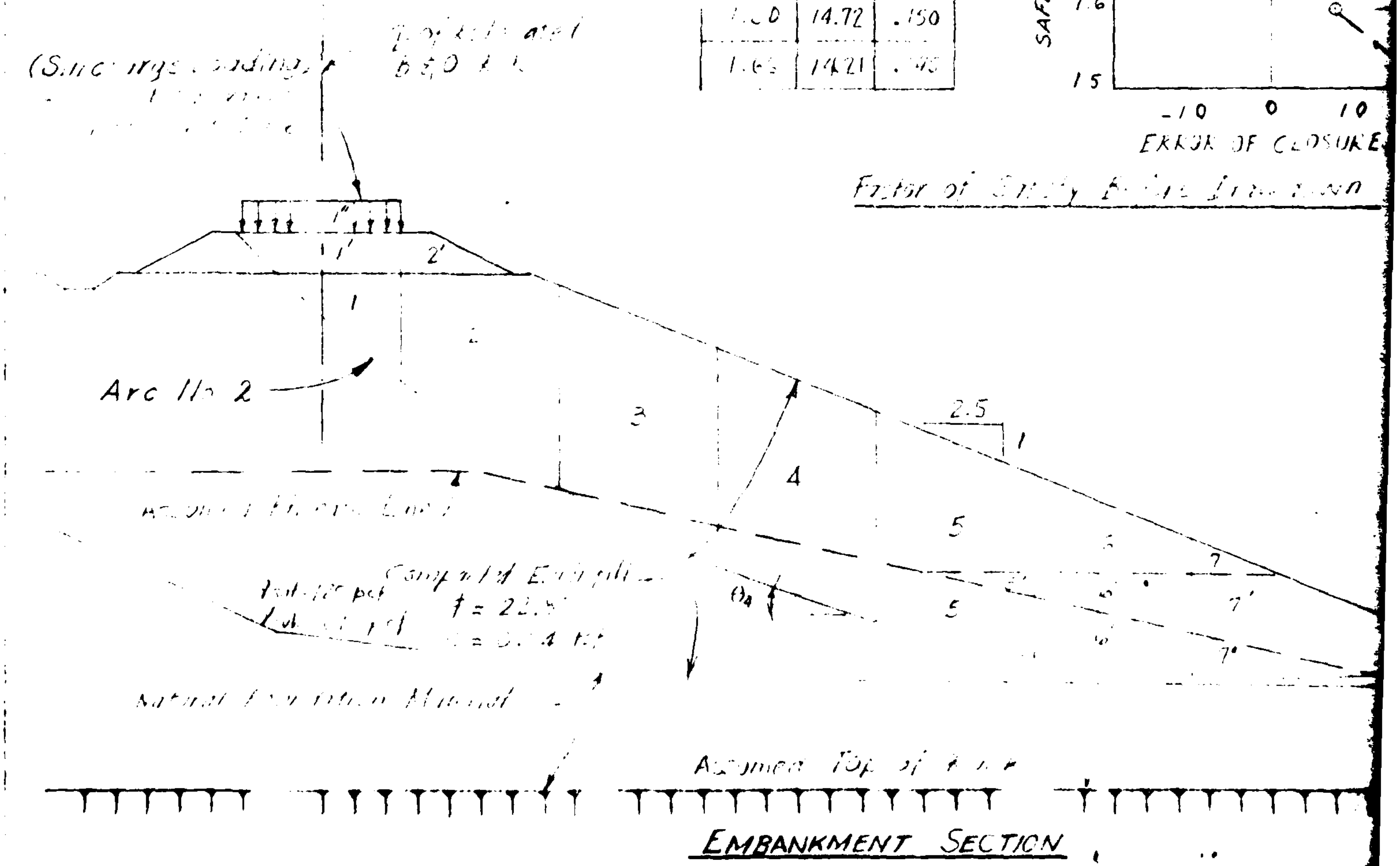
COMPUTATION OF FACTOR OF SAFETY - SUDDEN DR

SLICE	N_D KIPS	ϕ	$N_D \tan\phi$	[illegible]	[illegible]	W	θ	SIN
1	14.1	2[illegible]		10.[illegible]	[illegible]	10.26	42.5	.6
2	12.0			11.[illegible]	[illegible]	[illegible]	34.0	.5
3	14.1			[illegible]	[illegible]	[illegible]	26.1	.4
4	14.0			[illegible]	2.[illegible]	14.[illegible]	19.8	.3
5	12.[illegible]			[illegible]	.44	13.02	13.2	.2
6	9.9			[illegible]	[illegible]	10.[illegible]	6.7	.1
7	5.6			[illegible]	[illegible]	7.02	0.0	.0
[illegible]	2.0			9.00	[illegible]	2.48	-6.[illegible]	-.1
Σ	84.2		35.36		19.89			

F.S.	ϕ_D	C_D
[illegible]	22.8	.240
[illegible]	15.65	.160
[illegible]	14.72	.150
1.6[illegible]	14.21	.[illegible]



Factor of Safety [illegible]



EMBANKMENT SECTION

FETY - SUDDEN DRAWDOWN

W kips	θ	Sin θ	W sin θ kips
16.26	42.5	.676	10.99
[illegible]	34.0	.559	7.78
[illegible]	26.7	.449	7.14
14.91	19.8	.339	5.05
13.02	13.2	.228	2.97
10.75	6.7	.117	1.25
7.02	0.0	.000	0.0
2.48	-6.0	-.105	-0.26
			34.92

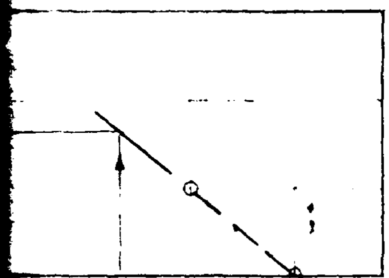
$$F.S. = \Sigma \frac{N_D \tan \phi + C \Delta L}{W \sin \theta}$$

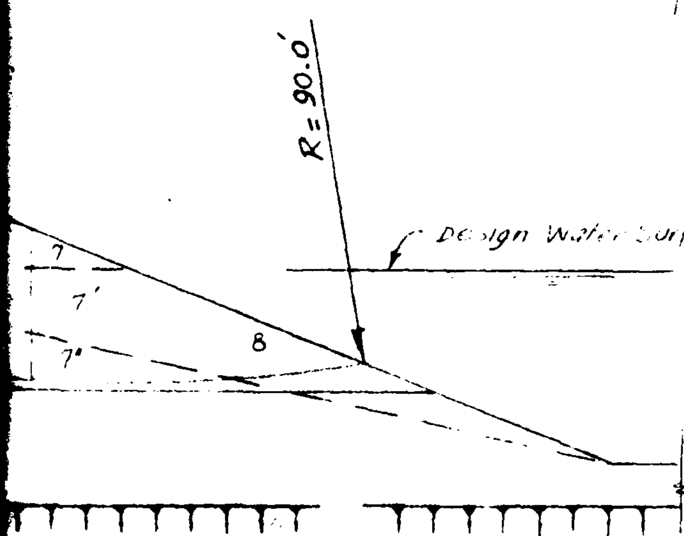
Where N_D = Normal Effective Force Before Drawdown.

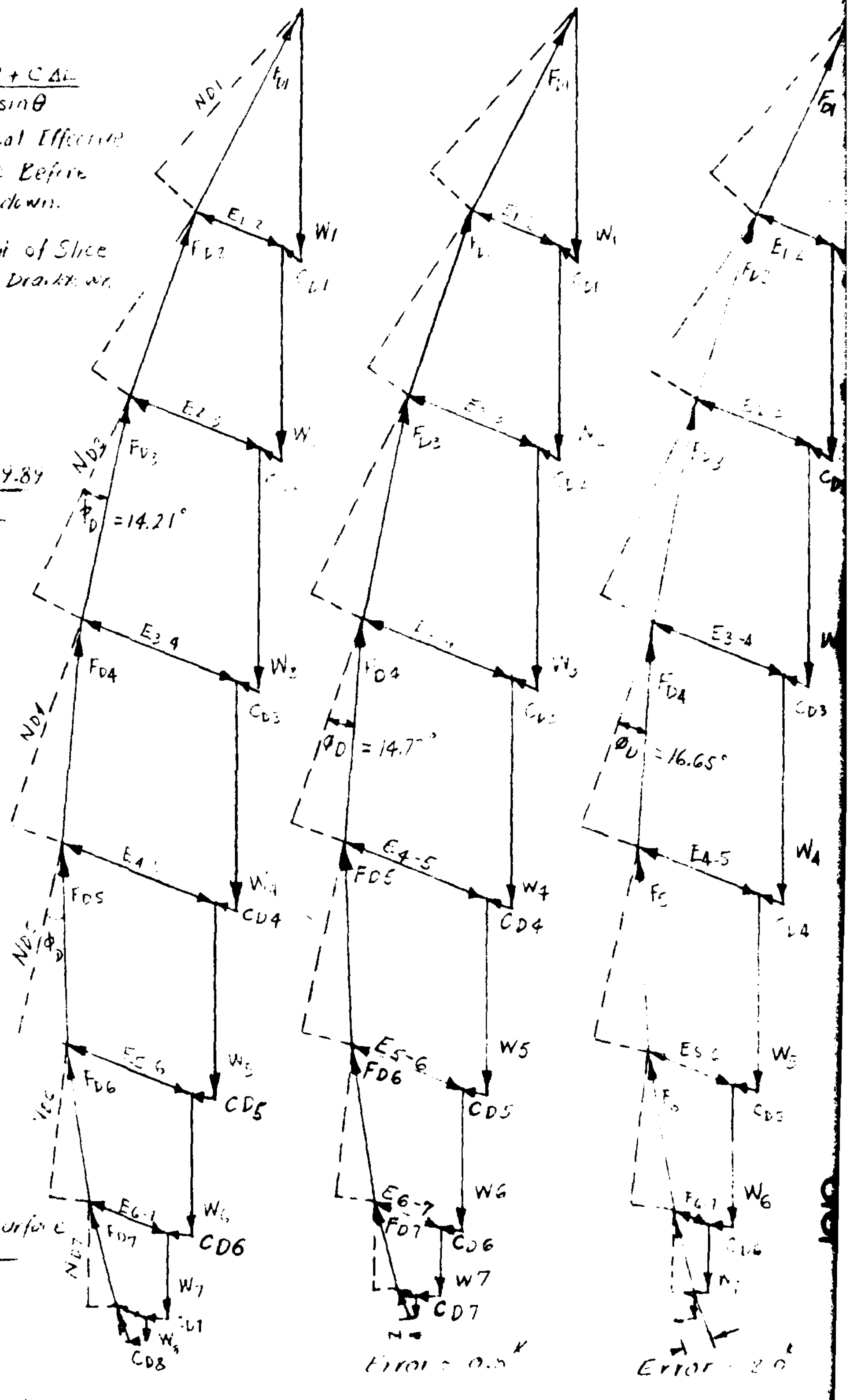
W = Weight of Slice After Drawdown.

$$F.S. = \frac{35.36 + 19.89}{34.92}$$

F.S. = 1.58

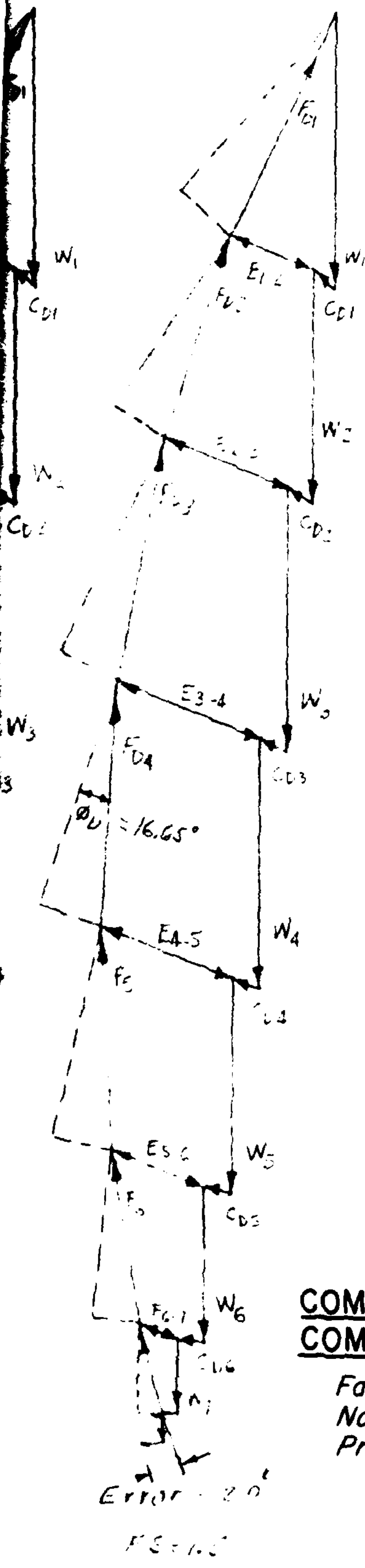






Composite Force Polygons Before Drawdown

Scale 1. IN = 10. KIP



MEASUREMENTS & WEIGHTS											
SLICE	HORIZ. WIDTH, FT	BASE LENGTH OF SLICE ΔL, FT	SLICE HEIGHT FT: LEFT SIDE	[illegible]	[illegible]	[illegible]	WEIGHT, KIPS: SUBMERGED	SATURATED	WT BEFORE DRAWDOWN	WT AFTER DRAWDOWN
1''								[illegible]		
1'					[illegible]		—	[illegible]	[illegible]	[illegible]
1	[illegible]	[illegible]			[illegible].45	[illegible].60	—	[illegible].45		
2'	4.5	1.8	[illegible]	[illegible]	[illegible]	[illegible]	—	1.41	[illegible]	[illegible]
2	[illegible]		[illegible]	13.[illegible]	[illegible]	[illegible].00	—	12.[illegible]		
3	10.0	11.0	12.0	11.0	[illegible]	120.0[illegible]	—	15.[illegible]	[illegible]	[illegible]
3'	10.0		[illegible]	[illegible]	[illegible]	[illegible]	0.88	—		
4	[illegible]	10.5	11.0	[illegible]	[illegible]	102.00	—	[illegible]	[illegible]	[illegible]
4'	[illegible]		—	3.2	[illegible]	32.[illegible]	[illegible]	—		
5	10.0	[illegible]0.2	9.4	6.2	7.8[illegible]	[illegible].20	—	9.70	[illegible]	12.02
5	[illegible]		[illegible]	[illegible]	[illegible]	[illegible].60	[illegible]	[illegible].70		
5	10.0		[illegible]	[illegible]	[illegible]80	[illegible]	2.5[illegible]	—		
6	10.0	10.0	6.2	[illegible]	[illegible]	41.00	—	[illegible]	[illegible]	[illegible]
6	[illegible]		1.6	[illegible]	[illegible]	27.[illegible]	[illegible]	[illegible]		
6	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—		
7	[illegible]	[illegible]	2.0	[illegible]	[illegible]	[illegible]	—	[illegible]	4.54	7.02
7	[illegible]		3.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
7	[illegible]		[illegible].8	[illegible]	[illegible]	[illegible]	[illegible]	—		
8	9.[illegible]	9.[illegible]	4.4	[illegible]	[illegible]	17.60	1.[illegible]	[illegible]	[illegible]	[illegible]

COMPARISON WITH COMPUTER RESULTS

Factor of Safety for Arc. No. 2 is 1.50 by Computer Program (See Plate D4-4)

Force Diagram

10. KIPS

BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

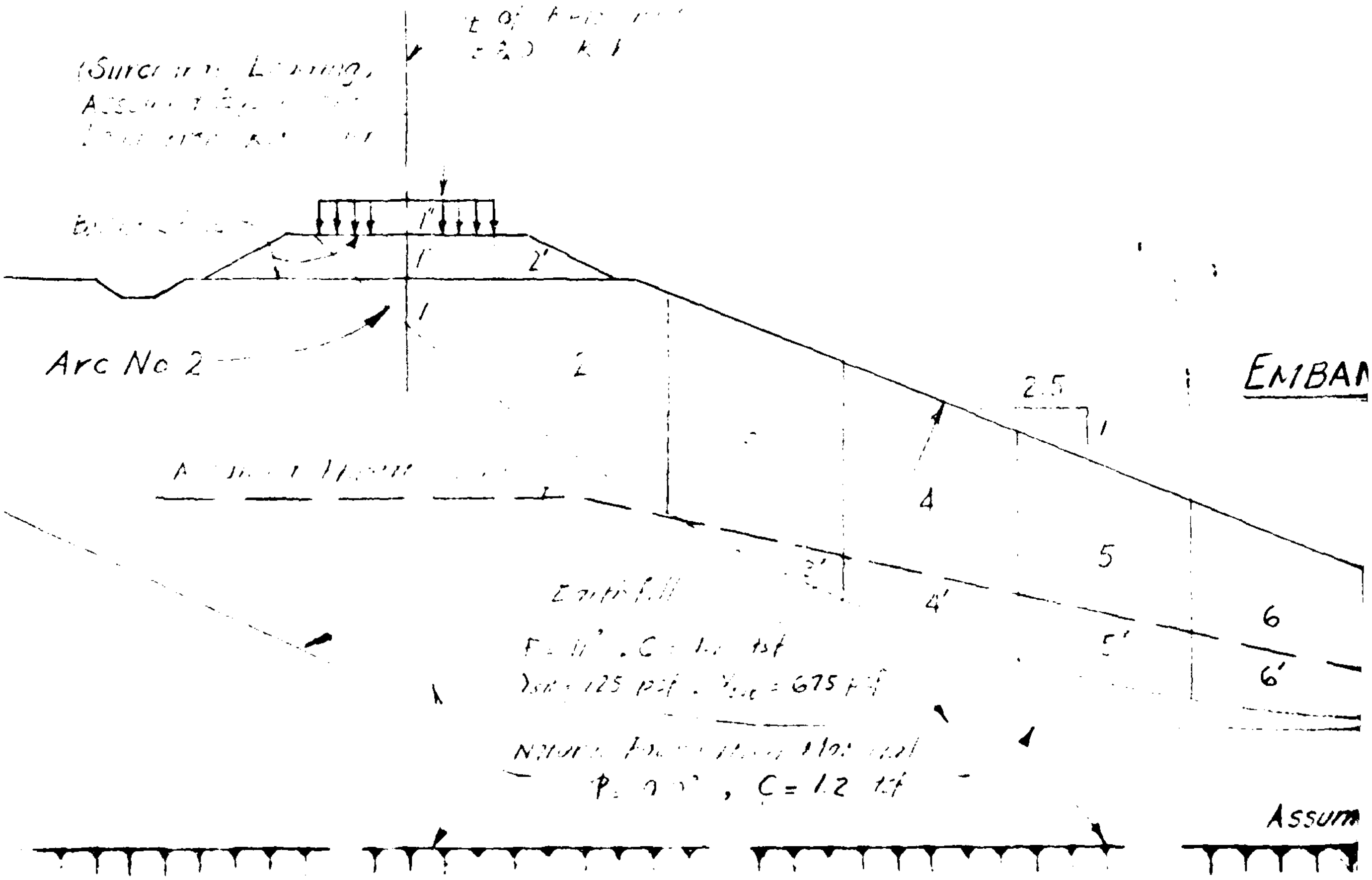
MANUAL CHECK COMPUTATIONS
LEFT BANK-FLOODWAY CHANNEL
STA. 89+50F
SUDDEN DRAWDOWN CONDITION

U. S. ARMY ENGINEER DISTRICT, BUFFALO
PHASE II GENERAL DESIGN MEMORANDUM

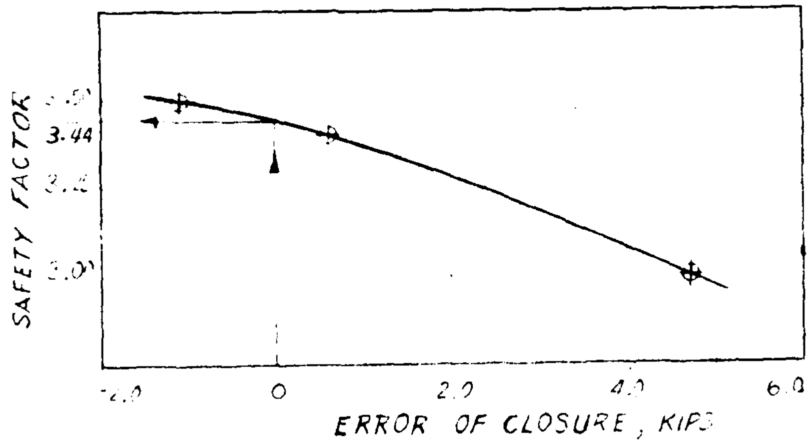
GANNETT FLEMING CORDDRY AND CARPENTER, INC.
CONSULTING ENGINEERS
HARRISBURG, PENNSYLVANIA

MARCH 1979

PLATE NO. D4-8

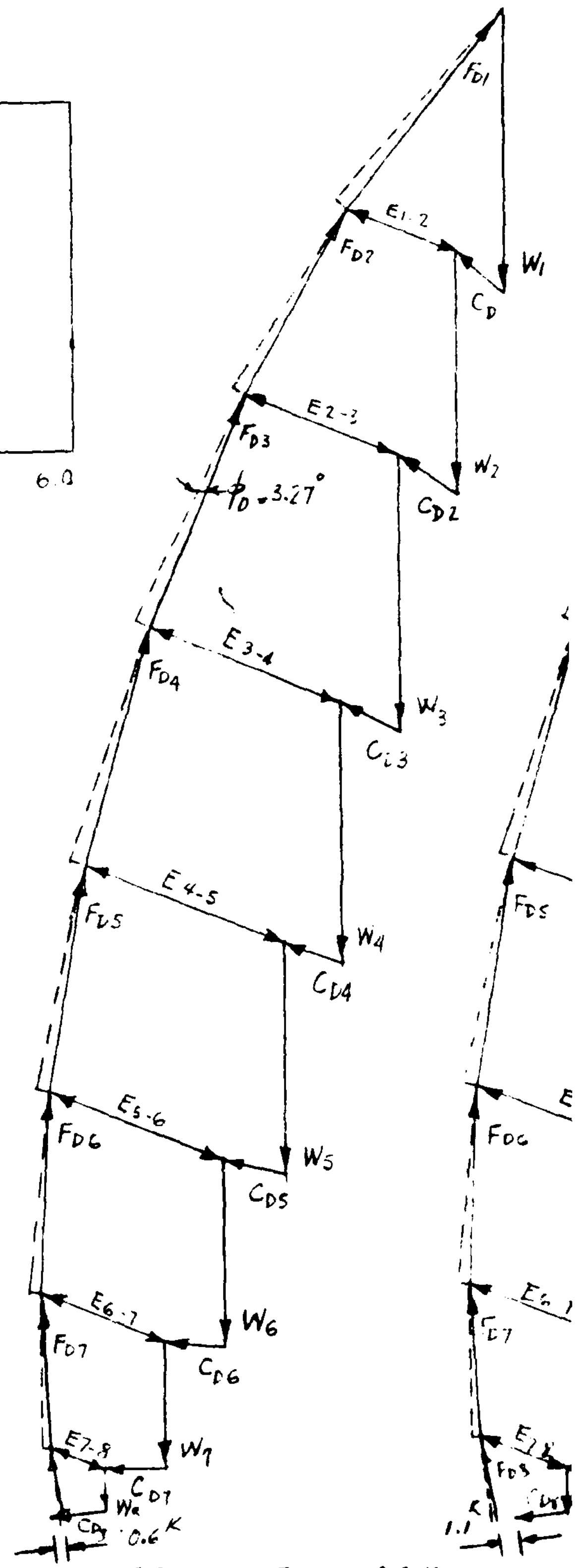


Arc No 2
2.5
1
1'
2'
4
4'
5
5'
6
6'



F.S.	ϕ_D degrees	C_D ksf
3.00	3.707°	0.400
3.40	3.272°	0.353
3.50	3.179	0.343

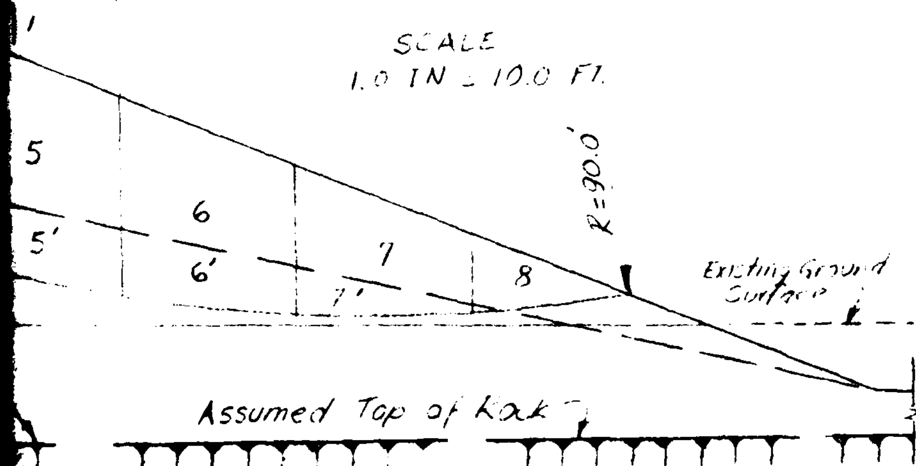
Factor of Safety Obtained = 3.44



F.S. = 3.4 , Error = 0.6 KIPS

EMBANKMENT SECTION

SCALE
1.0 IN = 10.0 FT.



COMPOSITE FORCE POLYGONS

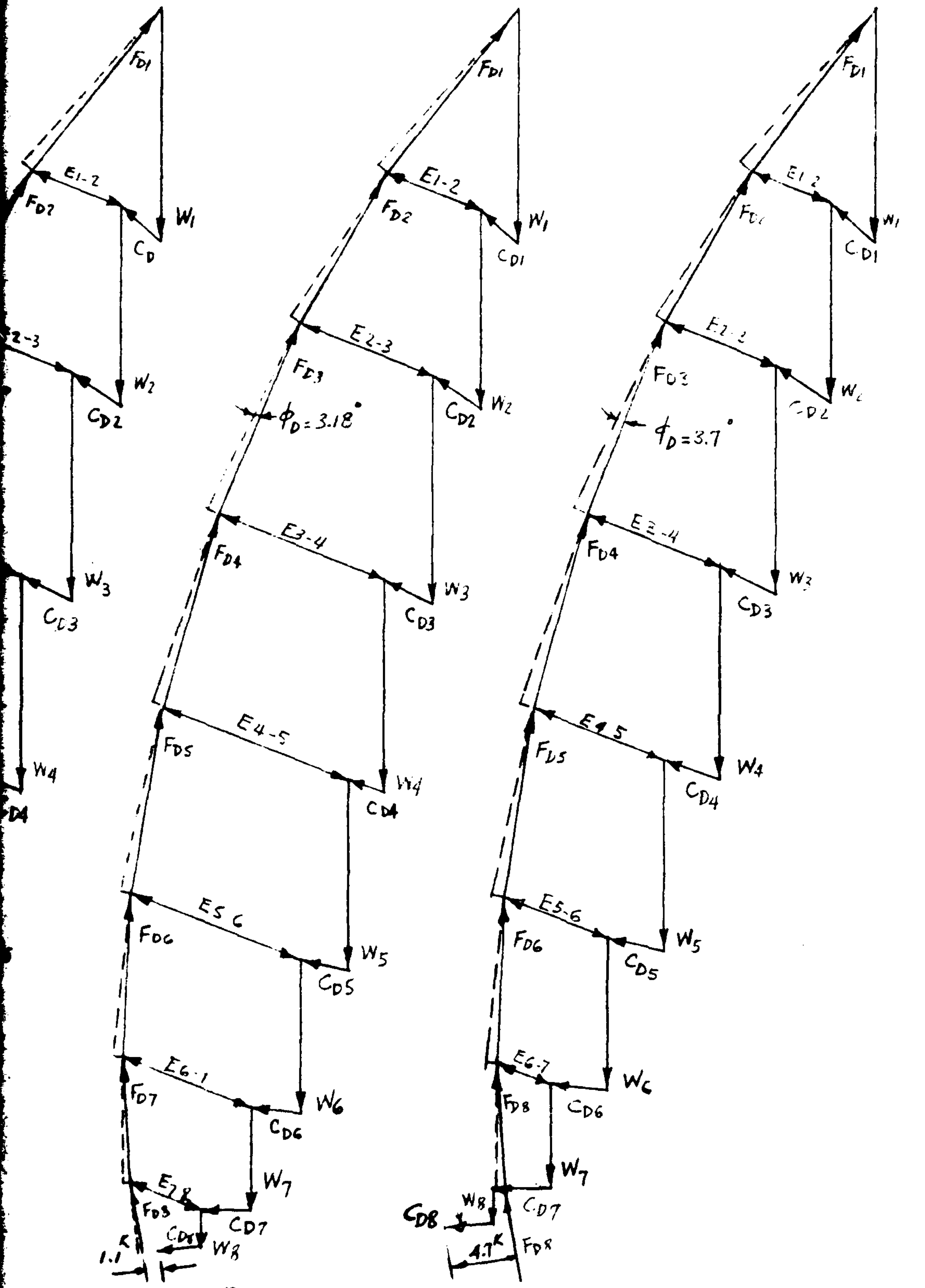
Scale 1.0 IN =

AD-A102 433 CORPS OF ENGINEERS BUFFALO NY BUFFALO DISTRICT F/G 13/2
BIG CREEK FLOOD CONTROL PROJECT, CLEVELAND, OHIO. PHASE II. GEN--ETC(U)
AUG 79

UNCLASSIFIED NL

4 OF 4
AD A
102433

END
DATE
FILMED
9-81
DTIC



[illegible] = 0.6 KIPS F.S. = 3.5 , Error = 1.1 KIPS F.S. = 3.0 , Error = 4.7 KIPS

[...]E POLYGONS FOR THREE TRIALS

[S]cale 1.0 IN = 10.0 KIPS

ME[...]				
SLICE No	[illegible]	[illegible]		
		LEFT SIDE	RIGHT SIDE	AVERAGE
1'				
1'	[illegible]		[illegible].5	[illegible].50
1	8.0		5[illegible]	[illegible].45
2'	[illegible].5	[illegible]	[illegible]	2.50
2	10.0	7[illegible]	[illegible]	10.00
3	10.0	[illegible]	11.0	[illegible].30
3'	10.0	0.0	2[illegible]	1.30
4	10.0	11.0	9.4	10.2
4'	10.0	2.6	3.5	3.2
5	10.0	9.4	7.8	8.6
5	10.0	3.8	3.8	3.8
6	10.0	7.8	5.8	6.8
6'	10.0	3.8	[illegible].8	3.3
7	10.0	5.8	4.0	4.9
7'	10.0	[illegible]	0.2	1.5
8	9.0	1.4	[illegible]	[illegible].2

COMPARISON [...]
COMPUTER R[...]

Factor of Saf[...]
No. 2 is 3.49 by [...]
Program. (See P[...]

MEASUREMENTS & WEIGHTS													
SLICE No	HORIZONTAL [illegible]	HEIGHT, FT			AREA OF SLICE	WEIGHT, KIPS			BASE LENGTH, ΔL FT	[illegible] C̄ΔL KIPS	[illegible] (FS=3.37)	FS=[illegible] (f=.18)	FS 3.34 (f=.27)
		LEFT SIDE	RIGHT SIDE	AVERAGE		SATURATED	SUBMERGED	TOTAL				C_p	[illegible]
1°						[illegible]	–						
1′	[illegible]	[illegible]	[illegible]	2.50	[illegible]	[illegible]	–	16.[illegible]	10.4	12.48	4.16	3.57	3.67
1	8.0	[illegible]	6.9	3.45	27.6	3.45	–						
2′	4.5	[illegible]	[illegible]	2.50	11.[illegible]	1.41	–	13.91	11.8	14.16	4.72	4.05	4.16
2	10.0	[illegible]	[illegible]	10.0[illegible]	100.0	1[illegible].50	–						
3	10.0	[illegible]	11.0	[illegible]	120.0	15.00	–	15.88	11.0	13.20	4.40	3.77	[illegible]
3′	10.0	0.0	[illegible]	1.30	13.0	–	[illegible]						
4	10.0	11.0	9.4	10.2	102.0	12.75	–	14.91	10.5	12.60	4.20	3.60	[illegible]
4′	10.0	2.6	3.8	3.2	32.0	–	2.16						
5	10.0	9.4	7.8	8.6	86.0	10.[illegible]	–	13.32	10.2	12.24	4.08	3.50	[illegible]
5	10.0	3.8	3.8	3.8	38.0	–	2.57						
6	10.0	7.8	5.8	6.8	68.0	8.50	–	10.73	10.0	12.00	4.00	3.43	[illegible]
6′	10.0	3.8	[illegible]	3.3	33.0	–	2.23						
7	10.0	5.8	4.0	4.9	49.0	6.12		7.14	10.0	1[illegible].00	4.00	3.43	[illegible]
7′	10.0	[illegible]	0.2	1.5	15.0	–	1.01						
8	9.0	4.4	[illegible]	[illegible]	[illegible]	2.47		[illegible]	9.0	10.80	3.60	3.09	3.15

COMPARISON WITH COMPUTER RESULTS

Factor of Safety for Arc No. 2 is 3.49 by Computer Program. (See Plate D4-4)

BIG CREEK FLOOD CONTROL PROJECT CLEVELAND, OHIO	
MANUAL CHECK COMPUTATIONS LEFT BANK - FLOODWAY CHANNEL STA. 89+50F END OF CONSTRUCTION CONDITION	
U. S. ARMY ENGINEER DISTRICT, BUFFALO PHASE II GENERAL DESIGN MEMORANDUM	
GANNETT FLEMING CORDDRY AND CARPENTER, INC. CONSULTING ENGINEERS HARRISBURG, PENNSYLVANIA	MARCH 1979
	PLATE NO. D4-9

BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

PHASE II
GENERAL DESIGN MEMORANDUM

APPENDIX D

DESIGN ANALYSIS

AUGUST 1979

SUBAPPENDIX D5

COMPUTATIONS FOR RAILROAD RELOCATIONS

SUBAPPENDIX D5

COMPUTATIONS FOR RAILROAD RELOCATIONS

CONTENTS

NOTE: The alignment geometry for the railroad relocations was obtained by using a computer program. The computer printout sheets in this Subappendix are from this program. A description of the program, general information, general rules, and index of commands for the program are at the end of this Subappendix on Pages D5-46 through D5-52, inclusive.

NOTE: The COGO Program has been verified by hand computations.

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Big Creek Flood Control Project FILE NO. 7622
B&O Railroad Relocation SHEET NO. ____ OF ____ SHEETS
FOR U.S. Army Corp of Engineers
COMPUTED BY RLH DATE 1/5/79 CHECKED BY WMIII DATE 1/5/78

B.&O MAINLINE

NOTE:

All horizontal and vertical curvature has been established by use of coordinated survey points. These coordinated survey points have been computed from U.S. Army Corp of Engineers survey of the project area. Horizontal curvature has been computed by ARC definition.

Design Criteria:

Chessie System Engineering Bulletin Number R-13
Dated - April 18, 1977

Governing Constraints:

(1) Mainline Design Speed —— 30 M.P.H.

(2) Mainline Gradient —— +1.50% Max.

(3) Mainline Curvature —— 4° 00' 00" Max (Spiraled)

Spiral Lengths:

Curve No. 1

Curvature = 6° 00' Existing
Superelevation = 3½" (by R-13) or match existing elevation.

Length of Spiral = 62 Ea.
= 62 (3.5)
= 217'

8813

Curve No. 2

Curvature = 4°00'
Superelevation = 2½" (by R-13)

Length of Spiral = 62 Ea.
= 62(2.5)
= 155'

Curve No. 3

Curvature = 1°00'
Superelevation = ½" (by R-13)

Length of Spiral = 62 Ea.
= 62(.5)
= 31'

Curve No. 4

Curvature = 4°00'
Superelevation = 2½" (by R-13)

Length of Spiral = 62 Ea.
= 62 (2.5)
= 155'

Curve No. 5

Curvature = 4° 00'
Superelevation = 2½" (by R-13)
Length of Spiral = Same as Curve No. 4 = 155'

6919

Chessie System

BULLETIN NUMBER R-13
EFFECTIVE DATE April 2[illegible], 197[illegible]
REVISED DATE April 19, 1977

ENGINEERING DEPARTMENT PROCEDURE BULLETIN

INSTRUCTIONS GOVERNING THE SUPERELEVATION OF THE OUTER RAIL AND THE SPEED OF TRAINS ON CURVES

Degree of Curve	SPEED IN MILES PER HOUR											
	20	25	30	35	40	45	50	55	60	65	70	75
0-15	0	0	1/4	1/4	1/4	1/2	1/2	1/2	3/4	3/4	1	1
0-30	1/4	1/4	1/4	1/2	1/2	3/4	3/4	1	1-1/4	1-1/2	1-3/4	2
0-45	1/4	1/2	1/2	3/4	3/4	1	1-1/4	1-1/2	1-3/4	2	2-1/2	3
1-00	1/4	1/2	1/2	3/4	1	1-1/4	1-1/2	2	2-1/4	2-3/4	3-1/4	3-3/[illegible]
1-15	1/2	1/2	3/4	1	1-1/4	1-3/4	2	2-1/2	3	3-1/2	4	4-3/[illegible]
1-30	1/2	1/2	1	1-1/4	1-1/2	2	2-1/2	3	3-1/2	4-1/4	5	5-1/[illegible]
1-45	1/2	3/4	1-1/4	1-1/2	2	2-1/2	3	3-1/2	4	4-3/4	5-3/4	
2-00	1/2	3/4	1-1/4	1-3/4	2-1/4	2-3/4	3-1/4	4	4-3/4	5-1/2		
2-15	3/4	1	1-1/2	2	2-1/2	3	3-3/4	4-1/2	5-1/4			
2-30	3/4	1	1-1/2	2	2-3/4	3-1/2	4-1/4	5	6			
2-45	3/4	1-1/4	1-3/4	2-1/4	3	3-3/4	4-3/4	5-1/2				
3-00	3/4	1-1/4	1-3/4	2-1/2	3-1/4	4	5	6				
3-15	1	1-1/2	2	2-3/4	3-1/2	4-1/2	5-1/2					
3-30	1	1-1/2	2-1/4	2-3/4	3-3/4	4-3/4	5-3/4					
3-45	1	1-3/4	2-1/4	3	4	5	6					
4-00	1	1-3/4	2-1/2	3-1/4	4-1/4	5-1/4						
4-30	1-1/4	2	2-3/4	3-3/4	4-3/4	6						
5-00	1-1/4	2	3	4	5-1/4							
5-30	1-1/2	2-1/4	3-1/4	4-1/2	5-3/4							
6-00	1-1/2	2-1/2	3-1/2	4-3/4								
6-30	1-3/4	2-3/4	3-3/4	5-1/4								
7-00	1-3/4	3	4-1/4	5-1/2								
7-30	2	3	4-1/2	6								
8-00	2-1/4	3-1/4	4-3/4									
8-30	2-1/4	3-1/2	5									
9-00	2-1/4	3-3/4	5-1/4									
9-30	2-1/2	3-3/4	5-1/2									
10-00	2-3/4	4	5-3/4									
10-30	2-3/4	4-1/4										
11-00	2-3/4	4-1/2										
11-30	3	4-3/4										
12-00	3	4-3/4										
14-00	3-3/4	5-3/4										
16-00	4-1/4											
18-00	4-3/4											
20-00	5-1/4											

$E = 0.00066DV^2$
E = Superelevation in Inches
D = Degree of Curve
V = Speed in Miles Per Hour

TABLE A
EQUILIBRIUM ELEVATION

Chessie System

BULLETIN NUMBER R-13
EFFECTIVE DATE April 28, 1970
REVISED DATE April 18, 1977

ENGINEERING DEPARTMENT PROCEDURE BULLETIN

INSTRUCTIONS GOVERNING THE SUPERELEVATION OF THE OUTER RAIL AND THE SPEED OF TRAINS ON CURVES

Degree of Curve	Elevation In Inches										
	0	½	1	1½	2	2½	3	3½	4	4½	5
0-30	76	84	93	100							
0-45	62	69	76	82	87	93	97	102			
1-00	53	60	65	71	76	80	85	89	93	96	100
1-15	48	52	59	63	68	72	76	79	83	86	89
1-30	44	49	53	58	62	65	69	72	76	79	82
1-45	40	45	50	54	57	61	64	67	70	73	76
2-00	38	42	46	50	53	57	60	63	65	68	71
2-15	36	40	44	47	50	54	56	59	62	64	67
2-30	34	38	41	45	48	51	53	56	59	61	63
2-45	32	36	40	43	46	48	51	54	56	58	60
3-00	31	35	38	41	44	46	49	51	53	56	58
3-15	30	33	36	39	42	45	47	49	51	54	56
3-30	29	32	35	38	40	43	45	47	49	52	53
3-45	28	31	34	37	39	41	44	46	48	50	52
4-00	27	30	33	35	38	40	42	44	46	48	50
4-30	25	28	31	33	36	38	40	42	44	45	47
5-00	24	27	29	32	34	36	38	40	41	43	45
5-30	23	25	28	30	32	34	36	38	40	41	43
6-00	22	24	27	29	31	33	35	36	38	39	41
6-30	21	23	26	28	30	31	33	35	36	38	39
7-00	20	23	25	27	29	30	32	34	35	36	38
7-30	20	22	24	26	28	29	31	32	34	36	37
8-00	19	21	23	25	27	28	30	31	33	34	35
8-30	18	20	22	24	26	28	29	30	32	33	34
9-00	18	20	22	24	25	27	28	30	31	32	33
9-30	17	19	21	23	25	26	27	29	30	31	32
10-00	17	19	21	22	24	25	27	28	29	30	32
10-30	16	18	20	22	23	25	26	27	29	30	31
11-00	16	18	20	21	23	24	26	27	28	29	30
11-30	16	18	19	21	22	24	25	26	27	28	29
12-00	15	17	19	20	22	23	24	26	27	28	29
14-00	14	16	17	19	20	21	23	24	25	26	27
16-00	13	15	16	18	19	20	21	22	23	24	25
18-00	13	14	15	17	18	19	20	21	22	22	23
20-00	12	13	15	16	17	18	19	19	20	21	22

TABLE C
MAXIMUM ALLOWABLE SPEED FOR FREIGHT TRAINS

D5-6

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Big Creek Flood Control Project FILE NO. 7622
B&O Railroad Relocation SHEET NO. ___ OF ___ SHEETS
FOR U.S. Army Corp of Engineers
COMPUTED BY RLH DATE 1/8/79 CHECKED BY WMIII DATE 1/12/79

B.&O. Spur to Industrial Park

NOTE: All horizontal and vertical curvature has been established by use of coordinated survey points. These coordinated survey points have been computed from U.S. Army Corp of Engineers survey of the project area. Horizontal curvature has been computed by Arc definition.

Design Criteria:

Chessie System Engineering Bulletin Number R-13 Dated April 18, 1977

Governing Constraints:

1) Spurline Curvature ———————— 14°00' Max (No Spirals)

2) Turnout Size ———————————— Number 8

Description:

The Spurline alignment is basically as per preliminary design with the following exceptions. The use of a Number 6 Turnout has been done away with and a Number 8 Turnout used in it's place. The C.T. which was located on the northern end of the proposed bridge carrying the siding to the industrial park, has been moved back off the bridge. To accomplish this, a minor alignment change was necessary. With the use of 14°00' curves and the number 8 turnout, we now have a satisitactory alignment both crossing the bridge

 (continued next sheet)

and tying into the existing trackage in the industrial park. This will however, create additional work beyond the preliminary design limit. This additional work will consist of placement of approximately 250 feet of additional new trackage plus the adjustment of an existing turnout and, therefor, also the adjustment of the trackage connected to this turnout.

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Big Creek Flood Control Project FILE NO. 7622
B&O Railroad Relocation SHEET NO. 1 OF ____ SHEETS
FOR U.S. Army Corp of Engineers
COMPUTED BY RLH DATE 1/8/79 CHECKED BY W.M.III DATE 1/12/79

INDEX SHEET FOR
HORIZONTAL & VERTICAL ALIGNMENT and
MISCELLANEOUS DESIGN
FOR
B.O. RAILROAD MAINLINE and SPURLINE

6819

BY RLH DATE 1/5/79 SUBJECT HORIZ. ALIGN. SHEET NO. 2 OF
CHKD. BY W.M. DATE 1/12/79 JOB. NO. 7622

TABULATION OF CURVE DATA

CURVE NO. 1

Exist = 6° 00' 00"
R = 954.93'
$L_{S_{OUT}}$ = 217.00'
LT = 144.76'
ST = 72.42'
E = 3½" or match exist
Throw = 2.054'

CURVE NO. 2

Δ = 6° 55' 38.33"
R = 1433.00'
D = 4° 00' 00"
Lc = 18.26'
Ls = 155.00'
E = 2½"
Throw = 0.70'

CURVE NO. 3

Δ = 1° 46' 41.41"
R = 5730.00"
D = 1° 00' 00"
Lc = 146.83'
Ls = 31.00'
E = ½"
Throw = 0.007'

D5-10

BY RLH	DATE 1/5/79	SUBJECT HORIZ. ALIGN.	SHEET NO 3 OF
CHKD. BY W.M.	DATE 1/12/79		JOB NO 7622

℄ TAB. CONTINUED

CURVE NO. 4

$\Delta = 21°54'38.77''$
$R = 1433.00'$
$D = 4°00'00''$
$Lc = 393.00'$
$Ls = 155.00'$
$E = 2\frac{1}{2}''$
Throw $= 0.70'$

CURVE NO. 5

$\Delta = 20°48'49.35''$
$R = 1433.00'$
$D = 4°00'00''$
$Lc = 365.56$
$Ls = 155.00'$
$E = 2\frac{1}{2}''$
Throw $= 0.70'$

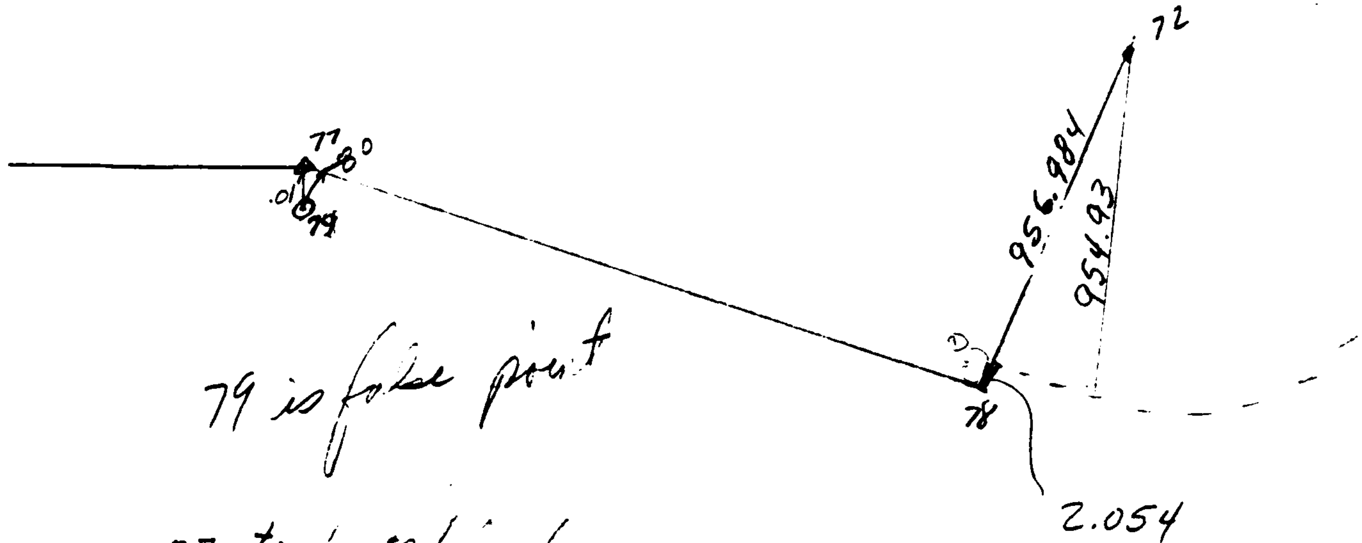
Job No. 7622 Sht. 4 of
By RLH Date 1/4/7?
Subject Final Horiz Align.

```
COMMAND:
?     str 77 648934.1354 2218679.1291
?     89 648729.5727 2218951.7035
?     92 649218.7935 2218185.2974
?     91 650438.333 2215909.1639
?     93 650521.8818 2215148.9075
?     40 650809.1256 2214587.2236
?     31 648522.0199 2219317.0641
?     87 648606.0543 2219129.9679
?     0 0 0

COMMAND:
?     seq 31 87 954.93 1 0
   ARC LENGTH=      205.4981          CHORD=      205.1018
?     0 0 0 0 0

COMMAND:
?     ibr 89 77
   NW  53-  6- 44.50    DIST=      340.7972
?     77 92
   NW  60-  2- 22.83    DIST=      570.0000
?     92 91
   NW  61- 49-  4.24    DIST=     2582.2588
?     91 93
   NW  83- 43- 43.01    DIST=      764.8334
?     93 40
   NW  62- 54- 53.66    DIST=      630.8707
?     0 0
```

Job No. 7622 Sht. 5 of ___
By RLH Date 1/4/79 Ckd ___
Subject Final Horiz Align
Exist 6° Curve Throw To
New Tangent for Spiral



79 is fake point

77 to be redefined

$$o = 0.1454\,\Delta\,S$$

$$.1454\,(6.5095^{*})(2.17) = 2.054$$

* Δ taken from spiral as previously run.

JOB NO ___
DATE ___
CHKD BY ___

Job No. 7622 Sht. 6 of
By RLH Date 1/4/79 Ch'd
Subject Final Horiz. Align

```
?      1 2 4 500
  4  648446.5711 2219908.8077
?      0 0 0 0

COMMAND:
?      ang
?      4 2 3
   6- 30- 34.25      DIST  2 TO   3=      72.4225
?      0 0 0

COMMAND:
?      eoj

END OF PROGRAM COG

EDIT  end
READY
```

D5-14

Job No. 7622 Sht. 7 of ___
By RCH Date 1/-/79
Subject Fire Morg. Align.

```
logon afcc2
THANK YOU.            DATE 12/27/78        TIME 12.18.03
READY edit cl(cog) ipli
EDIT  run

COMMAND:
?      sos
?      90
00140  SOS  0443         END OF FILE
EDIT  run

COMMAND:
?      str
?      10 649008.78 2218363.99
?      11 648554.50 2219251.42
?      21 649106.18 2218409.23
?      22 648599.40 2219319.79
?      6 650528.78 2215124.76
?      5 650855.32 2214515.40
?      9 649343.48 2217661.34
?      91 650438.333 2215909.1639- PI 138+75.27
?      8 650476.8864 2215558.3454
?      0 0 0

COMMAND:
?      lan 10 9 99 470.21 107 54 03.9
 99   649001.6761 2217338.4352
?      10
 31   648522.9199 2219317.06403.5
?
       0 0 0 0 0 0 0

COMMAND:
?      lan
?      10 11 31 73.24 179 13 03.5
 31   648522.9199 2219317.0641
?      22 21 52 584.78 00 18 00.3
 52   648819.1219 2218918.7055
?      22 21 51 661.14 181 21 31.2
 51   649441.3080 2217839.3218
?      10 11 32 10.18 228 10 37.7
 32   648544.6539 2219254.0058
?      10 11 33 26.80 339 11 25.1
 33   648557.4402 2219224.7818
?      10 11 34 126.64 354 58 38.5
 34   648602.1153 2219134.0724
?      10 11 35 425.31 359 57 27.5
 35   648748.0216 2218872.6879
?      10 11 36 575.00 00 15 03.2
```

DS-15

Job No. 7622 Sht. 8 of
By RLH Date 1/4/79 Ckd
Subject Final Horiz. Align

```
 36  648818.7498 2218740.7371
?      5 6 37 295.62 175 32 44.6
 37  650409.8078 2215395.3830
?      5 6 38 80.90 02 55 20.7
 38  650570.5773 2215055.4939
?      5 6 39 206.90 00 14 36.4
 39  650627.2792 2214942.8108
?      5 6 40 606.25 359 21 29
 40  650809.1256 2214587.2236
?      0 0 0 0 0 0 0

COMMAND:
?

       lan 9 99 61 353.96 255 10 02.2
 61  649170.7811 2217027.4832
?      9 99 62 155.32 258 58 23
 62  649084.7735 2217207.2136
?      9 99 63 96.07 3
                    261 02 28.5
 63  649055.9699 2217259.1785
?      9 99 64 40.86 29 30 18.9
 64  649013.7065 2217377.4840
?      9 99 65 97.1 47 54 49.8
 65  648999.4981 2217435.5108
?      9 99 66 250.06 57 25 58.2
 66  648954.8014 2217584.0625
?      9 99 67 11.35 165 25 55.2
 67  648991.7303 2217332.9667
?      9 99 68 64.82 103 52 02.4
 68  648947.1668 2217373.5119
?      9 99 69 161.77 48 11 30.7
 69  648997.2629 2217500.1450
?      9 99 70 321.61 46 35 13
 70  649001.9099 2217660.0451
?      9 99 71 402.15 47 00 37.4
 71  648998.9964 2217740.5763
?
```

Job No. 7622 Sht. 9 of
By RLH Date 1/4/78
Subject Final Horiz. Align

0 0 0 0 0 0 0

COMMAND:
? aai 72 33 954.93 31 954.93 22
72 649430.0509 2219612.6501
? 0 0 0 0 0 0

COMMAND:
? lan 51 52 73 20.00 -90 00 00
73 648801.7945 2218908.7175
? 52 51 74 20.00 90 00 00
74 649423.9805 2217829.3338
? 0 0 0 0 0 0 0

COMMAND:
? tof 98 72 34 35
98 648595.1274 2219146.5910
? 0 0 0 0

COMMAND:
? lln 98 35 75 -761.17
75 648224.1253 2219811.2242
? 0 0 0 0

COMMAND:
? lan 98 75 76 762.17 102 53 00
76 648789.3060 2220321.0776
? 0 0 0 0 0 0 0

COMMAND:
? lln 73 74 77 265
~~77 648934.1355 2218679.1271~~ Pt Rede[illegible]
? 0 0 0 0

COMMAND:
? lan 73 77 79 -.001 90 00 00
79 648934.1346 2218679.1286
? 75 76 4 2.054 -90 00 00
4 648787.9302 2220322.6027
? 0 0 0 0 0 0 0

COMMAND:
? tan 78 72 956.984 80 79 .001 1 -1
78 648664.6415 2219038.2227
80 648934.1354 2218679.1292

D5-17

Job No. 7622 Sht. 10 of
By RLH Date 1/4/79 Ckd
Subject Final Horiz. Align.

```
?      0 0 0 0 0 0 0 0

COMMAND:
?      pin 77 74 73 78 80
 77   648934.1354 2218679.1291  PI STA 107+23.30
?      81 76 75 78 77
 81   648140.8769 2219736.1252
?      0 0 0 0 0

COMMAND:
?      lln 81 78 1 -2.054
  1   648139.6440 2219737.7680
?      1 4 3 1000.000
  3   648882.1533 2220407.6037
?      1 4 90 -50.00
 90   648102.5185 2219704.2762
?      0 0 0 0

COMMAND:
?      ang 90 1 78
  84- 49- 59.70      DIST  1 TO  78=    874.6348
?

       0 0 0

COMMAND:
?      fit
?      82 3 1 954.93 217 217 84 49 59.70 1.0

             SPIRAL  IN
LT=      144.7646        ST=       72.4224
NTS      82   648869.3887 2220396.0885
NPI      83   648761.8997 2220299.1200
NSC      84   648713.9721 2220244.8249

             SIMPLE CURVE
NPI      85   648256.4040 2219726.4657
NC       86   649429.8830 2219612.8733

             SPIRAL  OUT
LT=      144.7646        ST=       72.4224
NCS      87   648606.0543 2219129.9679 — STA. 101+65.50
NPI      88   648642.6781 2219067.4883
NST      89   648729.5727 2218951.7035 — STA. 103+82.50
```

NOT NEEDED

D5-18

Job No. 7622 Sht. 11 of ___
By RLH Date 1/4/79 Ckd ___
Subject Final Horiz Align

```
       lln 77 74 92 570
 92  649218.7935 2218185.2974   PI 112+73.02
?      0 0 0 0

COMMAND:
?      ang 73 77 78
   6- 55- 38.36      DIST 77 TO  78=     448.9713
?
       0 0 0

COMMAND:
?      fit 53 1 77 1433.00 155 155 6 55 38.36
?      -1.0

            SPIRAL  IN
LT=      103.3492        ST=       51.6811
NTS      53  648835.5336 2218810.5134 — STA. 105+59.03
NPI      54  648897.5687 2218727.8533
NSC      55  648926.3104 2218684.9016 — STA. 107+14.03

            SIMPLE CURVE
NPI      56  648931.3869 2218677.3152
NC       57  647735.3559 2217887.9597

            SPIRAL  OUT
LT=      103.3492        ST=       51.6811
NCS      58  648936.3664 2218669.6647 — STA. 107+32.29
NPI      59  648964.5586 2218626.3503
NST      60  649016.1712 2218536.8115 — STA. 108+87.29

COMMAND:
?      ang 91 92 74
   1- 46- 41.38      DIST 92 TO  74=     410.8671
?      0 0 0

COMMAND:
?
       fit 41 77 92 5730 31 31 1 46 41.38 -1.0
```

Job No. 7622 Sht. 12 of
By RLH Date 1/4/73 Ckd
Subject Final Horiz Align

```
           SPIRAL IN
LT=      20.6667           ST=        10.3333
NTS     41   649166.6452 2218275.7655 — STA.111+88.60
NPI     42   649176.9661 2218257.8604
NSC     43   649182.1024 2218248.8940 — STA 112+19.60

           SIMPLE CURVE
NPI     44   649218.5954 2218185.1873
NC      45   644210.0712 2215400.7708

           SPIRAL OUT
LT=      20.6667           ST=        10.3333
NCS     46   649253.4442 2218120.5664 - STA. 113+66.43
NPI     47   649258.3491 2218111.4713
NST     48   649268.1094 2218093.2547 - STA. 113+97.43

COMMAND:
?      pin 93 40 39 91 8
 93  650521.8818 2215148.9075     PI 143+29.49
?      0 0 0 0 0

COMMAND:
?      lln 91 92 94 -100.00
 94  650485.5606 2215821.0188
?      93 40 95 -100.00
 95  650476.3505 2215237.9407
?      0 0 0 0

COMMAND:
?      ang 8 91 94
  21- 54- 38.77      DIST 91 TO  94=     100.0000
?      8 93 95
  20- 48- 49.32      DIST 93 TO  95=     100.0000
?      0 0 0

COMMAND:
?
```

Job No. 7622 Sht. 13 of
By RLH Date
Subject Ecc Horiz Align.

```
fit 13 92 91 1433 155 155 21 54 38.77 -1.0

            SPIRAL IN
LT=     103.3492        ST=       51.6811
NTS    13  650270.6670 2216222.0937 - STA 135+20.25
NPI    14  650319.4764 2216130.9965
NSC    15  650341.3859 2216084.1894 - STA 136+75.25

            SIMPLE CURVE
NPI    16  650425.2160 2215905.0968
NC     17  649043.5305 2215476.6861

            SPIRAL OUT
LT=     103.3492        ST=       51.6811
NCS    18  650457.4104 2215709.9938 - STA 140+68.25
NPI    19  650465.8246 2215659.0023
NST    20  650477.1143 2215556.2717 - STA 142+23.25

COMMAND:
?     fit 23 91 93 1433 155 155 20 48 49.32 1.0

            SPIRAL IN
LT=     103.3492        ST=       51.6811
NTS    23  650484.6532 2215487.6706 - STA. 142+92.26
NPI    24  650495.9429 2215384.9399
NSC    25  650504.3571 2215333.9484 - STA. 144+47.26

            SIMPLE CURVE
NPI    26  650534.2783 2215152.6215
NC     27  651918.2371 2215567.2561

            SPIRAL OUT
LT=     103.3492        ST=       51.6811
NCS    28  650608.9881 2214984.7134 - STA. 148+12.83
NPI    29  650629.9975 2214937.4954
NST    30  650677.0537 2214845.4804 - STA. 149+67.83

COMMAND:
?     arc 55 58 1433 1 0
~~55  647617.9249 2218476.4724~~
?
      0 0 0

COMMAND:
?     str 55 648926.3104 2218684.9016
?     0 0 0

COMMAND:
```

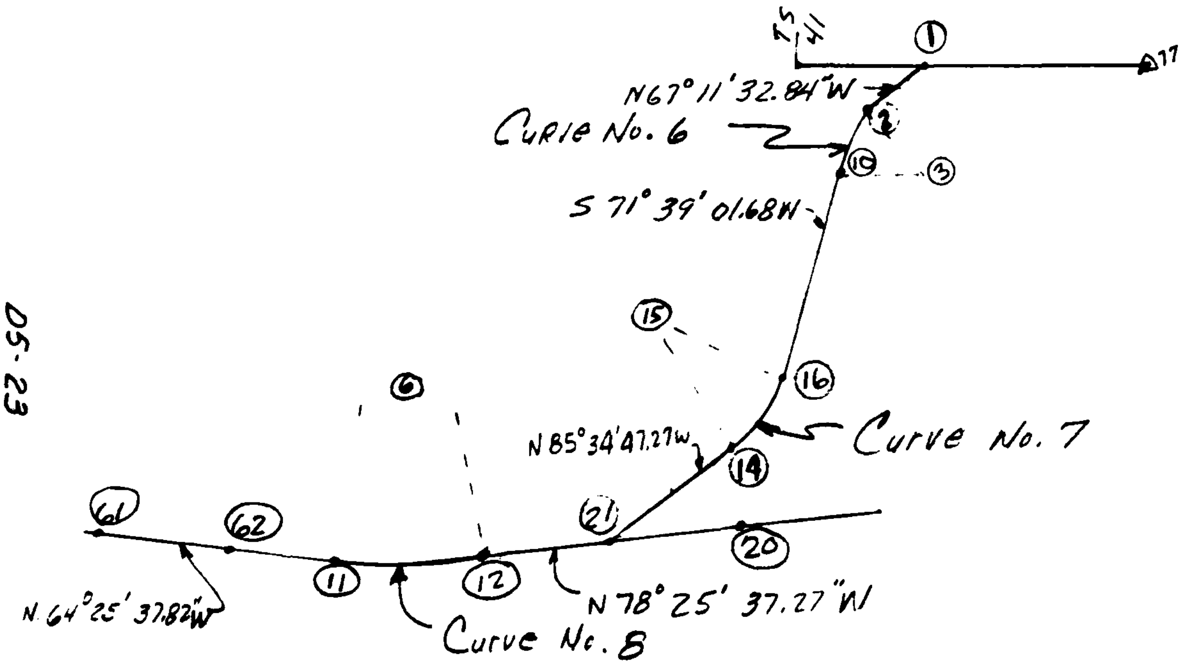
Job No. 7622 Sht. 14 of
By RLH Date 11/4/79 Ckd
Subject Final Horiz. Align

```
COMMAND:
?
     seq 55 58 1433 1 0
   ARC LENGTH=        18.2563          CHORD=        18.2562
?      43 46 5730 1 0
   ARC LENGTH=       146.8292          CHORD=       146.8252
?      15 18 1433 1 0
   ARC LENGTH=       393.0008          CHORD=       391.7703
?      25 28 1433 1 0
   ARC LENGTH=       365.5625          CHORD=       364.5720
?      0 0 000 0

COMMAND:
?
```

D5-22

Job No. 7622 Sht. 15 of
By RLH 1/4/79
Subject Final Horiz Align Points.



PI 1.	STA.	110 + 93.60
PC 2.	STA.	111 + 63.60
PT 10.	STA.	114 + 57.58
PC 16	STA.	118 + 59.60
PT 14	STA.	120 + 22.24
PI 21	STA.	120 + 92.24
PC 12	STA.	121 + 22.24
PT 11	STA.	122 + 22.24
Point 62	STA.	122 + 92.24
Point 61	STA	124 + 91.49

(N) = Siding Numbers

BY RLH DATE 1/5/79 SUBJECT HORIZ. ALIGN SHEET NO 16 OF
CHKD BY ______ DATE ______ JOB NO 7622

TABULATION OF CURVE DATA

(Siding - No Spirals)

Curve No. 6.

$\Delta = 41°09'25.48$
$R = 409.26'$
$D = 14°00'00''$
$Lc = 293.98$
$E = 0$

Curve No. 7

$\Delta = 22°46'11.05''$
$R = 409.26'$
$D = 14°00'00''$
$LC = 162.64'$
$E = 0$

PI @ Point 21 $\Delta = 7°09'10''$ - PI of No. 8 T.O.

Curve No. 8

$\Delta = 13°59'59.45''$
$R = 409.26'$
$D = 14°00'00''$
$Lc = 100.00'$
$E = 0$

Job No. 7622 Sht. 17 of ___
By RLH Date 1/4/79 Ck'd ___
Subject Final Horiz Align (Siding)

```
COMMAND:
?     str 41 649166.6452 2218275.7655
?     61 649170.7811 2217027.4832 - SURVEY POINT-STA. 124+91.49
?     77 648934.1354 2218679.1291
?     62 649084.7735 2217207.2136- SURVEY POINT-STA. 122+92.24
?     0 0 0

COMMAND:
?     lln 41 77 1 95.00
  1  649119.2022 2218358.0708 - STA. 110+ 93.60  PI  OF  NO. 8  TURNOUT.
?     0 0 0 0

COMMAND:
?     lan 41 2
              1
                2 70 -7 09 10
  2  649146.3368 2218293.5439 - PC  STA  111+63.60
?     1 2 3 409.26 90 00 00
  3  648769.0759 2218134.8996
?     0 0 0 0 0 0 0

COMMAND:
?     lln 62 61 11 -70.00
 11  649054.5574 2217270.3562 -  PT  STA. 122+22.24
?     0 0 0 0

COMMAND:
?     lan 62 11 13 409.26 90 00 00
 13  649423.7252 2217447.0166
?     0 0 0 0 0 0 0

COMMAND:
?     arc 12 13 -100.00 11
 12  649022.7855 2217364.9125  - PC  STA. 121+22.24
?     0 0 0 0

COMMAND:
?     lan 13 12 20 100.00 90 00 00
```

Job No. 7622 Sht. 18 of
By RLH Date 1/4/79
Subject Final Horiz Align (Siding)

```
 20  649002.7239 2217462.8795
?      13 12 22
               + 30.00 90 00 00
 21  649016.7070 2217394.3026 -PI STA 120+92.24
?      20 21 14 70.00 -7 09 10
 14  649011.3221 2217464.0944- PT. STA. 120+22.24
?      21 14 15 409.26 90 00 00
 15  649419.4148 2217495.6363
?      0 0 0 0 0 0 0

COMMAND:
?      tan 16 15 409.26 -1 -1
?      0 0 0 0 0 0
00180  TAN  0402       INV ARRY SUBSC
EDIT  run

COMMAND:
?      tan
?      16 15 409.26 10 3 409.26 -1 -1
 16  649030.9642 2217624.4767 - PC  STA. 118+59.60
 10  649157.5266 2218006.0592   PT  STA  114+57.58
?

       0 0 0 0 0 0 0 0

COMMAND:
?      ibr
?      1 2
   NW  67- 11- 32.84   DIST=       70.0000
?      10 16
   SW  71- 39-  1.68   DIST=      402.0239
?      14 21
   NW  85- 34- 47.27   DIST=       70.0000
?      21 12
   NW  78- 25- 37.27   DIST=       30.0000
?      62 61
   NW  64- 25- 37.82   DIST=      199.2494
?      0 0

COMMAND:
?      seq 2 10 409.26 1 0
   ARC LENGTH=     293.9823        CHORD=      287.7024
?      16 14 409.26 1 0
   ARC LENGTH=     162.6427        CHORD=      161.5746
?      0 0 0 0 0
```

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT ____ FILE NO. ____
____ SHEET NO. 19 OF ____ SHEETS
FOR ____
COMPUTED BY ____ DATE ____ CHECKED BY ____ DATE ____

B & O RAILROAD MAINLINE
VERTICAL ALIGNMENT

D5-27

6613

Job No. 7622 Sht. 20 of
By RLH Date 1/4/79 Ckd
Subject Engi Vert Align

```
PVI STA. & EL., NEAR & FAR GRADES(%), VC LENGTH?
?     10343.55 613.888 0.62 1.18 280

PVC STA=    102+03.550      PVT STA=    104+83.550
PVC ELEV=      613.020      PVT ELEV=      615.540
M.O.=    0.196

START STA., INC., END STA.?
?     10200.00 25 11900.00
```

STATION	ELEVATION	TANGENT SLOPE(%)
102+00.000	612.998	0.6200
102+25.000	613.157	0.6629
102+50.000	613.329	0.7129
102+75.000	613.514	0.7629
103+00.000	613.711	0.8129
103+25.000	613.920	0.8629
103+50.000	614.142	0.9129
103+75.000	614.377	0.9629
104+00.000	614.624	1.0129
104+25.000	614.883	1.0629
104+50.000	615.155	1.1129
104+75.000	615.440	1.1629
105+00.000	615.734	1.1800
105+25.000	616.029	1.1800
105+50.000	616.324	1.1800
105+75.000	616.619	1.1800
106+00.000	616.914	1.1800
106+25.000	617.209	1.1800
106+50.000	617.504	1.1800
106+75.000	617.799	1.1800
107+00.000	618.094	1.1800
107+25.000	618.389	1.1800
107+50.000	618.684	1.1800
107+75.000	618.979	1.1800
108+00.000	619.274	1.1800
108+25.000	619.569	1.1800
108+50.000	619.864	1.1800
108+75.000	620.159	1.1800
109+00.000	620.454	1.1800
109+25.000	620.749	1.1800
109+50.000	621.044	1.1800
109+75.000	621.339	1.1800

Job No. 7622 Sht. 21 of
By RLH Date 1/4/79
Subject Final Vert. Align

110+00.000	621.634	1.1800
110+25.000	621.929	1.1800
110+50.000	622.224	1.1800
110+75.000	622.519	1.1800
111+00.000	622.814	1.1800
111+25.000	623.109	1.1800
111+50.000	623.404	1.1800
111+75.000	623.699	1.1800
112+00.000	623.994	1.1800
112+25.000	624.289	1.1800
112+50.000	624.584	1.1800
112+75.000	624.879	1.1800
113+00.000	625.174	1.1800
113+25.000	625.469	1.1800
113+50.000	625.764	1.1800
113+75.000	626.059	1.1800
114+00.000	626.354	1.1800
114+25.000	626.649	1.1800
114+50.000	626.944	1.1800
114+75.000	627.239	1.1800
115+00.000	627.534	1.1800
115+25.000	627.829	1.1800
115+50.000	628.124	1.1800
115+75.000	628.419	1.1800
116+00.000	628.714	1.1800
116+25.000	629.009	1.1800
116+50.000	629.304	1.1800
116+75.000	629.599	1.1800
117+00.000	629.894	1.1800
117+25.000	630.189	1.1800
117+50.000	630.484	1.1800
117+75.000	630.779	1.1800
118+00.000	631.074	1.1800
118+25.000	631.369	1.1800
118+50.000	631.664	1.1800
118+75.000	631.959	1.1800
119+00.000	632.254	1.1800

```
ODD STATION?
?     10160.00
ELEV=    612.750      TAN. SLOPE=    0.6200%
?      0
```

Job No. 76__ Sht. 22 of ___
By RLH Date _-79 Ckd ___
Subject Fire ert. Align
℄

```
EDIT  run
PVT STA. & EL., NEAR & FAR GRADES(%), VC LENGTH?
?     12000.00 633.43 1.18 0.4 200.00

PVC STA=    119+00.000      PVT STA=    121+00.000
PVC ELEV=       632.250     PVT ELEV=       633.830
M.O.=   0.195

START STA., INC., END STA.?
?     11950.00 25 14400.00
```

STATION	ELEVATION	TANGENT SLOPE(%)
119+50.000	632.791	0.9850
119+75.000	633.025	0.8875
120+00.000	633.235	0.7900
120+25.000	633.420	0.6925
120+50.000	633.581	0.5950
120+75.000	633.717	0.4975
121+00.000	633.830	0.4000
121+25.000	633.930	0.4000
121+50.000	634.030	0.4000
121+75.000	634.130	0.4000
122+00.000	634.230	0.4000
122+25.000	634.330	0.4000
122+50.000	634.430	0.4000
122+75.000	634.530	0.4000
123+00.000	634.630	0.4000
123+25.000	634.730	0.4000
123+50.000	634.830	0.4000
123+75.000	634.930	0.4000
124+00.000	635.030	0.4000
124+25.000	635.130	0.4000
124+50.000	635.230	0.4000
124+75.000	635.330	0.4000
125+00.000	635.430	0.4000
125+25.000	635.530	0.4000
125+50.000	635.630	0.4000
125+75.000	635.730	0.4000
126+00.000	635.830	0.4000
126+25.000	635.930	0.4000
126+50.000	636.030	0.4000
126+75.000	636.130	0.4000
127+00.000	636.230	0.4000

Job No. 7622 Sht. 23 of ___
By RLH Date 1/4/79 Ckd ___
Subject Final Vert. Align.

127+25.000	636.330	0.4000
127+50.000	636.430	0.4000
127+75.000	636.530	0.4000
128+00.000	636.630	0.4000
128+25.000	636.730	0.4000
128+50.000	636.830	0.4000
128+75.000	636.930	0.4000
129+00.000	637.030	0.4000
129+25.000	637.130	0.4000
129+50.000	637.230	0.4000
129+75.000	637.330	0.4000
130+00.000	637.430	0.4000
130+25.000	637.530	0.4000
130+50.000	637.630	0.4000
130+75.000	637.730	0.4000
131+00.000	637.830	0.4000
131+25.000	637.930	0.4000
131+50.000	638.030	0.4000
131+75.000	638.130	0.4000
132+00.000	638.230	0.4000
132+25.000	638.330	0.4000
132+50.000	638.430	0.4000
132+75.000	638.530	0.4000
133+00.000	638.630	0.4000
133+25.000	638.730	0.4000
133+50.000	638.830	0.4000
133+75.000	638.930	0.4000
134+00.000	639.030	0.4000
134+25.000	639.130	0.4000
134+50.000	639.230	0.4000
134+75.000	639.330	0.4000
135+00.000	639.430	0.4000
135+25.000	639.530	0.4000
135+50.000	639.630	0.4000
135+75.000	639.730	0.4000
136+00.000	639.830	0.4000
136+25.000	639.930	0.4000
136+50.000	640.030	0.4000
136+75.000	640.130	0.4000
137+00.000	640.230	0.4000
137+25.000	640.330	0.4000
137+50.000	640.430	0.4000
137+75.000	640.530	0.4000

Job No. 7622 Sheet 24 of
By RLH Date 1/4/77 Chkd
Subject Final Vert. Align.

138+00.000	640.630	0.4000
138+25.000	640.730	0.4000
138+50.000	640.830	0.4000
138+75.000	640.930	0.4000
139+00.000	641.030	0.4000
139+25.000	641.130	0.4000
139+50.000	641.230	0.4000
139+75.000	641.330	0.4000
140+00.000	641.430	0.4000
140+25.000	641.530	0.4000
140+50.000	641.630	0.4000
140+75.000	641.730	0.4000
141+00.000	641.830	0.4000
141+25.000	641.930	0.4000
141+50.000	642.030	0.4000
141+75.000	642.130	0.4000
142+00.000	642.230	0.4000
142+25.000	642.330	0.4000
142+50.000	642.430	0.4000
142+75.000	642.530	0.4000
143+00.000	642.630	0.4000
143+25.000	642.730	0.4000
143+50.000	642.830	0.4000
143+75.000	642.930	0.4000
144+00.000	643.030	0.4000

ODD STATION?
? 0

END OF PROGRAM VC

Job No. 7622 Sht. 25 of
By RLH Date 1/4/79 Ckd
Subject Final Vert. Align

```
EDIT  run
PVI STA. & EL.. NEAR & FAR GRADES(%). VC LENGTH?
?     14546.14 643.61 0.4 0.74 200

PVC STA=   144+46.140      PVT STA=   146+46.140
PVC ELEV=      643.210     PVT ELEV=     644.350
M.O.=    0.085

START STA.. INC.. END STA.?
?     14425.00 25 14850.00

     STATION       ELEVATION      TANGENT SLOPE(%)
    144+25.000      643.125            0.4000
    144+50.000      643.225            0.4066
    144+75.000      643.332            0.4491
    145+00.000      643.450            0.4916
    145+25.000      643.578            0.5341
    145+50.000      643.717            0.5766
    145+75.000      643.866            0.6191
    146+00.000      644.026            0.6616
    146+25.000      644.197            0.7041
    146+50.000      644.378            0.7400
    146+75.000      644.563            0.7400
    147+00.000      644.748            0.7400
    147+25.000      644.933            0.7400
    147+50.000      645.118            0.7400
    147+75.000      645.303            0.7400
    148+00.000      645.488            0.7400
    148+25.000      645.673            0.7400
    148+50.000      645.858            0.7400

ODD STATION?
?     14857.90
ELEV=   645.917     TAN. SLOPE=   0.7400%
?     0

END OF PROGRAM VC

EDIT
```

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT ______ FILE NO. ______
SHEET NO. 26 OF ______ SHEETS
FOR ______
COMPUTED BY ______ DATE ______ CHECKED BY ______ DATE ______

B & O RAILROAD SPURLINE
VERTICAL ALIGNMENT

D5-34

8812

Job No. 7622 27
By RLH Date 1/4/79
Subject Final Vert Align
SIDING

```
 run
PVI STA. & EL., NEAR & FAR GRADES(%), VC LENGTH?
?     11211.27 624.13 1.18 -0.643 100

PVC STA=    111+61.270     PVT STA=    112+61.270
PVC ELEV=      623.540     PVT ELEV=      623.808
M.O.=    0.228
CURVE HIGH POINT=     623.922 STATION=    112+25.998

START STA., INC., END STA.?
?     11125.00 25 11650.00

      STATION       ELEVATION      TANGENT SLOPE(%)
     111+25.000      623.112            1.1800
     111+50.000      623.407            1.1800
     111+75.000      623.685            0.9297
     112+00.000      623.860            0.4740
     112+25.000      623.921            0.0182
     112+50.000      623.869           -0.4375
     112+75.000      623.720           -0.6430
     113+00.000      623.559           -0.6430
     113+25.000      623.398           -0.6430
     113+50.000      623.238           -0.6430
     113+75.000      623.077           -0.6430
     114+00.000      622.916           -0.6430
     114+25.000      622.755           -0.6430
     114+50.000      622.595           -0.6430
     114+75.000      622.434           -0.6430
     115+00.000      622.273           -0.6430
     115+25.000      622.113           -0.6430
     115+50.000      621.952           -0.6430
     115+75.000      621.791           -0.6430
     116+00.000      621.630           -0.6430
     116+25.000      621.469           -0.6430
     116+50.000      621.309           -0.6430

ODD STATION?
?
?     0

END OF PROGRAM VC
```

Job No. 7622 Sht. 28 of
By RLH Date 1/4/78 Ckd
Subject Final Vert Align. Grading

```
EDIT  run
PVI STA. & EL., NEAR & FAR GRADES(%), VC LENGTH?
?     11670.00 25
                6
               621.18 -0.643 -1.3281 100

PVC STA=   116+20.000      PVT STA=   117+20.000
PVC ELEV=      621.501     PVT ELEV=     620.516
M.O.=   0.086

START STA., INC., END STA.?
?     11675.00 25 12100.00
```

STATION	ELEVATION	TANGENT SLOPE(%)
116+75.000	621.044	-1.0198
117+00.000	620.768	-1.1911
117+25.000	620.449	-1.3281
117+50.000	620.117	-1.3281
117+75.000	619.785	-1.3281
118+00.000	619.453	-1.3281
118+25.000	619.121	-1.3281
118+50.000	618.789	-1.3281
118+75.000	618.457	-1.3281
119+00.000	618.125	-1.3281
119+25.000	617.793	-1.3281
119+50.000	617.461	-1.3281
119+75.000	617.129	-1.3281
120+00.000	616.797	-1.3281
120+25.000	616.465	-1.3281
120+50.000	616.133	-1.3281
120+75.000	615.801	-1.3281
121+00.000	615.469	-1.3281

```
ODD STATION?
?     0

END OF PROGRAM VC
```

05 · 36

Job No. 7622 Sht. 29 of
By RLH Date 1/4/79 Ckd
Subject Final Vert. Align.
Siding

```
EDIT  run
PVI STA. & EL.. NEAR & FAR GRADES(%). VC LENGTH?
?     12172.24 614.51 -1.3281 0.74 100

PVC STA=   121+22.240      PVT STA=   122+22.240
PVC ELEV=     615.174      PVT ELEV=     614.880
M.O.=   0.259
CURVE LOW POINT=     614.747 STATION=   121+86.458

START STA., INC., END STA.?
?     12125.00 25 12200.00

       STATION      ELEVATION      TANGENT SLOPE(%)
     121+25.000      615.138           -1.2710
     121+50.000      614.885           -0.7540
     121+75.000      614.760           -0.2370
     122+00.000      614.766            0.2801

ODD STATION?
?     12291.49
ELEV=   615.392      TAN. SLOPE=   0.7400%
?     0

END OF PROGRAM VC

EDIT  end
READY logoff
LOGGED OFF AT  13.59.55  01/04/79
‡SESSION DURATION  00.24.34  CPU TIME USED   60153/300THS SEC.
```

DRAINAGE OF TRACK AREAS

The Drainage has been studied with the following results:

1). The drainage area between the Norfolk & Western Railroad and the Relocated B&O R.R. from Fulton Road to Sta. 147± is considered not to have been disturbed or altered and will drain as present conditions allow.

2). The drainage area between the N&W RR. and the Relocated B.&O. RR. from Sta. 118+50± to Sta. 147± is approximately 4 Acres in size. This area will be drained with the use of a one(1) foot deep ditch below subgrade between the tracks and on a percent of grade equal to that of the top of rail. This will be outletted through a 18" Reinforced Cement Concrete Pipe Class IV, under the B.&O. Railroad and to the top of slope. A paved slope ditch will carry the discharge from the 18" RCP down the slope to the channel.

3) The drainage area between the N&W R.R. and the B.&O. R.R. from Pearl Road to 118+50± is approx. 1/2 acre in size. This area will drain by use of the normal swale between tracks (0.5' deep) and on a grade equal to that of the top of rail. This will be intercepted by a small headwall 10 feet west of the proposed Mainline B.O. R.R. Bridge abutment. This will be outletted through a 15" Reinforced Cement Concrete Pipe, Class IV placed through the abutment allowing water to free fall into channel.

4) The drainage area east of Pearl Road between N&W and B.&O. tracks will be drained by one (1) foot deep ditch located as shown on plans and outletted directly to Big Creek.

5.) The drainage area on the north side of the B.&O. Spur line between the tracks and the channel will drain as existing conditions permit.

6) The drainage area on the south side of the Spurline will be drained by use of a one (1) foot deep ditch located at the toe of Slope and graded to drain directly toward the channel.

Drainage Ref. - U.S Dept of Transportation
Hydraulic Eng. Circular No 12
Hydraulic Design Series No. 3

Area Between Tracks (Sta. 118+50 Rt to Pearl)

Avg. Length 800' x Avg. Width 26' ÷ 43560 = .48 Ac.

Use: 10 year storm, C = .6 $(n)_{ditch}$ = .025

El. 633
− 620
S = 13 ÷ 800 .016 $K = \frac{800}{\sqrt{.016}}$ = 6275.7 ÷ 1000 = 6.3

From chart: Time = 5 min

$T_{conc} = T_{Duration}$

intensity = 2(2.22)(1.6) = 7.1"/hr.

Q = (.6)(7.1)(.48) = 2.04 CFS. V = 2.6 fps

This will drain with swale between tracks carried to bridge abut & outlet pipe through abut.

Use 15" RCCP

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Drainage between tracks FILE NO. ____
SHEET NO. 33 OF ____ SHEETS
FOR ____
COMPUTED BY RLH DATE 1/8/79 CHECKED BY W.M. DATE 1/25/79

Area Between Tracks (Fulton to Sta. 118+50 RT)

Avg. Length 2850' x Avg. Width 63' ÷ 43,560' = **4.12 Ac.**

Use: 10 year storm $C = .6$ n(ditch) = .025

El. 650
- 633

$S = 17 \div 2850 = .00596$ $K = \frac{2850}{\sqrt{.00596}} = 36916.6 \div 1000 = 36.92$

From Chart: Time = 21 min.

$T_{conc} = T_{Duration}$

intensity = (2)(1.25)(1.6) = 4"/hr.

$Q = (.6)(4")(4.12) = 9.9$ c.f.s. $V = 2.72$ f.p.s.

Ditch 1' deep 2:1 sides = depth in ditch of 0.95'

Use 18" CL. IV

Use 3'-0" min. cover

From Concrete Design Manual Loading on pipe = 3955 #/ft
(E72 Design Loading - Impact Included)
Assume CL. C Bedding $LF = 1.5$
Factor of Safety 1.0

$D_{0.01} = \frac{3955}{1.5 \times 1.5} \times 1.0 = 1758$ #/Lin ft inside dia.

From AASHO M170 - Use CL III RCCP

Job No. 7622 Sht. 34 of ___
By RLH Date 4-79 Ckd ___
Subject Coordinated Survey Points

D5-42

```
?       0 0 0

COMMAND:
?   •  str 10 649008.78 2218363.99
?       11 648554.50 2219251.42
?       21 649106.18 2218409.23
?       22 648599.40 2219319.79
?       6 650528.78 2215124.76
?       5 650855.32 2214515.40
?       9 649343.48 2217661.34
?       91 650438.3333 2215909.1639
?       8 650476.8864 2215558.3454
?       0 0 0

COMMAND:
?       lan 10 9 99 470.21 107 54 03.9
 99    649001.6761 2217338.4352
?       10 11 31 73.24 179 13 03.5
 31    648522.0199 2219317.0641
?       22 21 52 584.78 00 18 0.3
 52    648819.1219 2218918.7055
?       22 21 51 661.14 181 21 31.2
 51    649441.3080 2217839.3218
?       10 11 32 10.18 228 10 37.7
 32    648544.6539 2219254.0058
?       10 11 33 26.80 339 11 25.1
 33    648557.4402 2219224.7818
?       10 11 34 126.64 354 58 38.5
 34    648602.1153 2219134.0724
?       10 11 35 425.31 359 57 27.5
 35    648748.0216 2218872.6879
?       10 11 36 575.00 00 15 03.2
 36    648818.7498 2218740.7371
?       5 6 37 295.62 175 32 44.6
 37    650409.8078 2215395.3830
?       5 6 38 80.9 02 55 20.7
 38    650570.5773 2215055.4939
?       5 6 39 206.90 00 14 36.4
 39    650627.2792 2214942.8108
?       5 6 40 606.25 359 21 29
 40    650809.1256 2214587.2236
?       0 0 0 0 0 0 0

COMMAND:
?       lan 9 99 61 353.96 255 10 02.2
 61    649170.7811 2217027.4832
?       9 99 62 155.32 258 58 23
 62    649084.7735 2217207.2136

?
        9 99 63 96.07 261 02 28.5
 63    649055.9699 2217259.1785
?       9 99 64 40.86 29 30 18.9
 64    649013.7065 2217377.4840
?       9 99 65 97.10 47 54 49.8
 65    648999.4981 2217435.5108
?       9 99 66 250.06 57 25 58.2
 66    648954.8014 2217584.0625
?       9 99 67 11.35 165 25 55.2
 67    648991.7303 2217332.9667
?       9 99 68 64.82 103 52 02.4
 68    648947.1668 2217373.5119
?       9 99 69 161.77 48 11 30.7
 69    648997.2629 2217500.1450
?       9 99 70 321.61 46 35 13
 70    649001.9099 2217660.0451
?       9 99 71 402.15 47 00 37.4
 71    648998.9964 2217740.5763
?       0 0 0 0 0 0 0
```

CONTROL POINT	CORR. CHAINED DIST.	CORR. EDM DIST.
MON. 121 to 122		1042.10'
121 to N&W-1 51		601.14'
121 to N&W-2 52		584.78'
~~MON. 111 to 110~~		
111 to B&O-1 31	73.24'	
111 to B&O-2 32	10.18'	
111 to B&O-3 33	26.80'	
111 to B&O-4 34		126.64'
111 to B&O-5 35		425.31'
111 to B&O-6 36		575.00'
MON. 106 to 105		691.35'
106 to B&O-7		295.62'
106 to B&O-8		80.90'
106 to B&O-9		206.90'
106 to B&O-10 40		606.25'
MON. 109 to 109A		470.21'
109A to B&O S1 41		353.96'
109A to B&O S2 42		155.32'
109A to B&O S3 43	96.07'	
109A to B&O S4 44	40.86'	

CONT.'D on PG. 2A

7

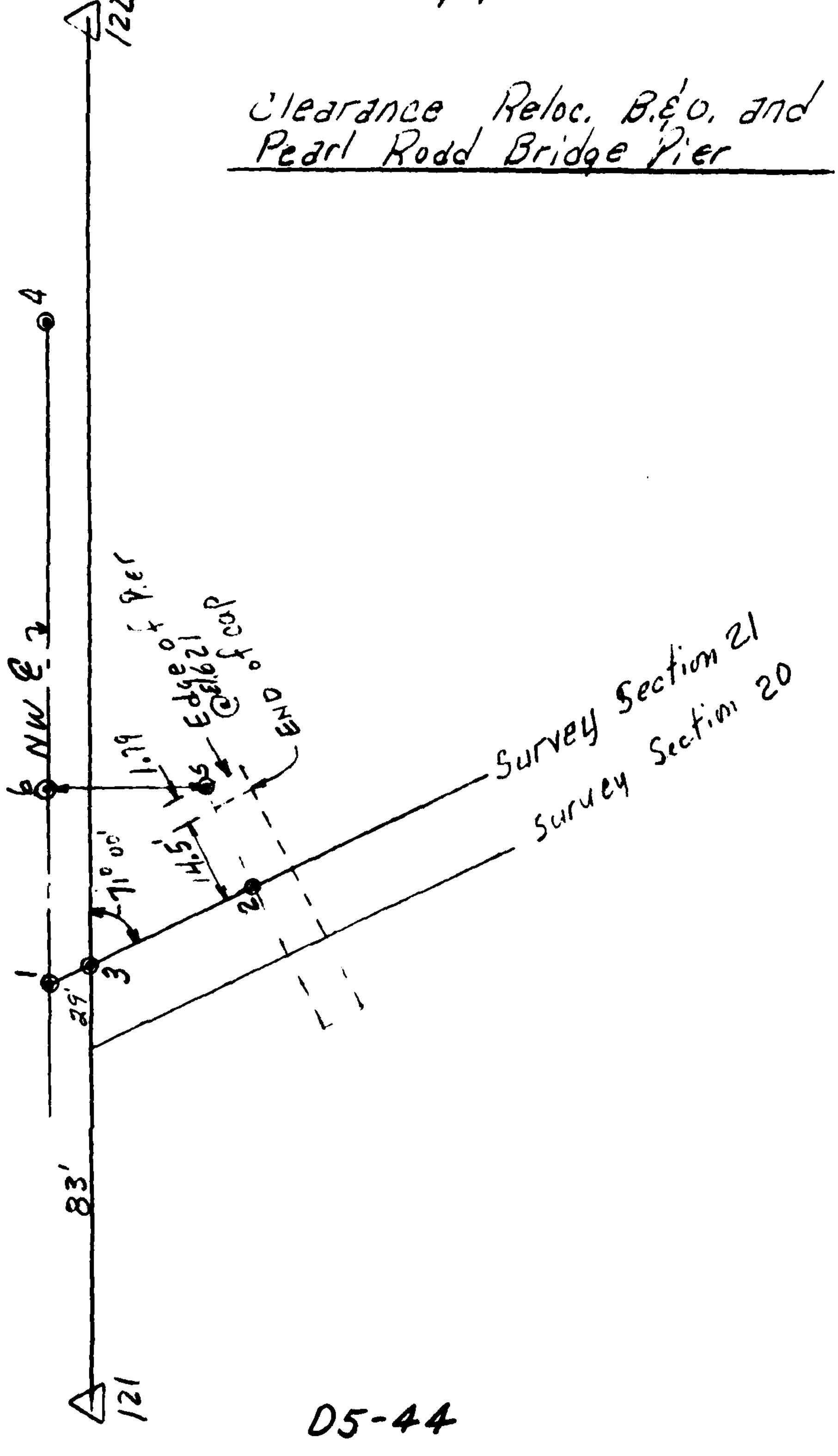
35 (2A)

CONTROL POINT	CORR. CHAINED DIST.	CORR. EDM DIST.
109A to B&O S5	97.10'	
109A to B&O S6		250.06'
109A to B&O S7	11.35'	
109A to B&O S8	64.82'	
109A to B&O S9		161.77'
109A to B&O S10		321.61'
109A to B&O S11		402.15'

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Big Creek Flood Control Project FILE NO. 7622
B.&O. Railroad Relocation SHEET NO. 36 OF ___ SHEETS
FOR U.S. Army Corp of Engineers
COMPUTED BY RLH DATE 1/10/79 CHECKED BY ___ DATE ___

Clearance Reloc. B.&O. and Pearl Road Bridge Pier



D5-44

6013

Job No. 7622 Sht. 37 of
By RLH Date 1/9/79 Ckd
Subject clearance Reloc B&O. 2nd Pearl Road Bridge* Pier.

*West 25th Street Bridge

```
      str 3 1000.000 1000.000
?     0 0 0

COMMAND:
?     laz 3 1 4.0 0 00 00
  1     1004.0000    1000.0000
?     0 0 0 0 0 0

COMMAND:
?     lln 3 1 2 -50.00
  2      950.0000    1000.0000
?     0 0 0 0

COMMAND:
?     lan 3 2 5 16.29 90 00 00
  5      950.0000    1016.2900
?     2 1 4 50.00 -71 00 00
  4      987.7216    1047.2759
?     0 0 0 0 0 0 0

COMMAND:
?     tof 6 5 1 4
  6      993.2617    1031.1862
?     0 0 0 0

COMMAND:
?     dis 6 5
    45.754498
?     0 0

COMMAND:
?     eoi

END OF PROGRAM COG

EDIT  end
READY logoff
```

CLR = 45.75
-20.00 ℄ Tracks
25.75' ℄ To Face of pier

GANNETT FLEMING CORDDRY & CARPENTER, INC.

Program No. 175

IBM SYSTEM/360

COGO

April, 1973

D5-46

DESCRIPTION OF PROGRAM

General Concept

The COGO programming system is designed specifically for civil engineering geometry problems. It may, however, be used in other application areas; in fact, there is almost no limit to the applicability of the system concept.

COGO is based on a vocabulary used by the engineer to state his problem. The statement of the problem in this familiar vocabulary and the input of these statements to the computer are all that is necessary to generate the solution to the problem. No programming, in the usual sense of the word, is necessary.

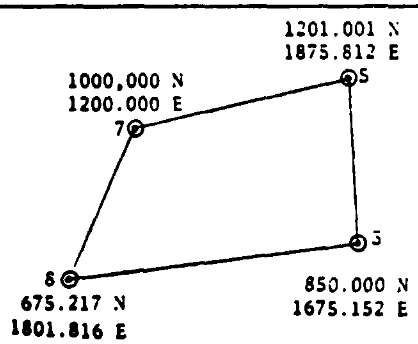
For example, an engineer interested in determining the area of the enclosed plat 7-5-3-8 states the problem as shown in Figure 1. The information in Figure 1 (with the exception of the diagram) is entered into the computer and the area is typed out automatically. One begins by giving the known information to the computer and then commanding it to perform specific functions on the known or previously calculated data. In this case the command AREA is used. It asks the computer to find the AREA of the enclosed polygon. Appearing right after the command is the result, so that the engineer can follow the sequence of calculation and keep a high degree of familiarity with the problem.

If the engineer wants the distance between points 5 and 8, he enters the command DISTANCE 5-8. The distance between points 5 and 8 is then typed out by the computer.

In practice, the engineer, using a sketch of his problem, writes the description of his problem and how to solve it as if he were solving it by hand. As a guide he follows the command descriptions shown later in this manual. Once he has written the commands on paper, he has a "computer program" for his problem. He then punches these on cards for entry into the 360. No intermediate programming is necessary.

Basis of System

The COGO Programming system is based on the repetitive use, by many different programs, of common data storage. This common data storage area is known as the "coordinate table". The engineer uses the COGO vocabulary to locate points on a traverse, subdivision, or along some alignment, etc. The points may be used in later calculations by other COGO commands and may be printed for immediate use. The engineer gives each point an identification number and refers to that point by number whenever it is needed.




```
STORE    7   1000.000   1200.000
         3    850.000   1675.152
         8    675.217   1801.816
         5   1201.001   1875.812

AREA     7  5  3  8  7

AREA = 184463.3598  sq ft. = 4.23 ACRES

DISTANCE  5 8

From PT 5 to PT 8 DIST = 952.3016
```

FIGURE 1

GENERAL INFORMATION

Operators. In 360 COGO, distances, angles, and azimuths can be specified by using an operator (a single character) and the required number of identifying points. For example, if two points of a line are know but the unknown distance is required as part of a command, the operator D may be used as follows to input the distance:

D 21 22

(where points 21 and 22 are the two known points of the line). In this case, if the operator were not used, the distance would have to be calculated either manually or by a previous run.

The following operators will be used to denote values to be calculated from known points:

Operator	Points	Description
D	XXX YYY	Denotes a straight-line distance from point XXX to point YYY.
A	XXX YYY	Denotes the Azimuth from point XXX to point YYY.
G	XXX YYY ZZZ	Denotes the angle at point YYY, clockwise from XXX to ZZZ.

At least one blank must be used before an operator but is optional after the operator. A blank must appear between the point numbers.

Bearings. Bearings are entered into command cards by either the quadrant method or the N,S,E,W delimiter method. In the former, a bearing is entered as quadrant, degrees, minutes, and seconds. The quadrant is coded as follows: NE=1, SE=2, SW=3, NW=4. For example, 1 30 05 58.0 is the code for N 30° 5'58.0"E.

In the delimiter method, the angle must be bracketed by the characters S or N (on the left) and E or W (on the right). At least one blank must precede each delimiter; blanks following a delimiter are optional. Looking at the same example as above, N 30 05 58.0 E is the code for N 30° 5'58.0" E.

Angles and azimuths. Angles and azimuths are entered as degrees, minutes, and seconds. For example 75 0 5.0 is the code for 75° 0' 5.0". (However, degree of curvature is given in decimal degrees.)

Note that at least one blank column separates degrees from minutes, and minutes from seconds. Degrees and minutes should be entered as integer quantities; the seconds must contain a decimal point and can contain decimal digits as well. Only the degrees portion carries a sign. To conform with practice, azimuths must be entered as positive quantities, measured clockwise from the north.

Zeros and small negative angles. Zeros must be included in the data. For example, an angle of zero degrees, zero minutes, and zero seconds must be entered as 0 0 0.0.

With counterclockwise angles (negative angles) of less than one degree (for example, -0 12 27.0), use the 360° complement of the angle as the clockwise angle, since minus zero is not distinguishable from plus zero. In the example given, -0 12 27.0 must be entered as 359 47 33.0.

Coordinate System

360 COGO uses a Y (North), X (East) coordinate system. Therefore coordinates must be entered in this order. The output is also given in this order.

Legal Numbers

For input to any COGO command, the user is permitted a maximum of 16 numerical characters plus a deciaml and a minus sign. (Leading and trailing zeros are counted as numeric characters.)

COGO Output

The output of a COGO job is printed out on the printer. The output format has answers interspersed with the listing of the input commands. The one exception to this is the LOTS/COMP command which has the listing of the input command suppressed to improve the output format.

When cards are punched as output to the Dump Command, the cards are punched in the Store Command format in order that these same cards may be used for a future run as store command input.

Coordinates and Curves

Up to 2000 points can be stored in 360 COGO. Number points from 1 to 2000. Up to 50 curves can be stored and referenced. Number curves from 1 to 50.

GENERAL RULES

There are some general rules which should be followed when writing COGO Input. Following the rules listed below can amount to a considerable saving of both time and computer costs by eliminating unnecessary reruns due to carelessly written input.

1. Write clearly on input forms.
2. Supply all necessary data for each command.
3. Use the CLEAR Command at the start of a new job.
4. Use the END/OF/JOB Command at the end of each run.
5. Numerical input must not begin before column 12 when using Long Form Command.
6. Numerical Input must not begin before column 5 when using Short Form Command.
7. The first column of a Comment Card shall contain an Asterisk (*) - the comment itself shall not start before column 5 and must end before column 73.
8. An Asterisk (*) after the last input data on each card allows a comment to be written in the remaining portion of the card. This comment must end before column 73.
   NOTE: Allow at least one blank space between the last piece of data and the Asterisk.
9. Angles are input in degrees, minutes, and seconds.
10. Minus angles must be signed for degrees only.
11. The LOTS/COMP Command cannot be used once Plotting has been initiated by the SCALE Command (#63) and until Plotting has been completed by the SCALE Command (#75).

INDEX OF COMMANDS

Number	Long Form	Short Form
1	END/OF/JOB	EOJ
2	STORE	STR
3	CLEAR	CLR
4	DUMP	DMP
5	*	*
6	REDEFINE	RED
7	EJECT	EJT
8	DISTANCE	DIS
9	LOCATE/AZIMUTH	LAZ
10	LOCATE/BEARING	LBR
11	LOCATE/ANGLE	LAN
12	LOCATE/LINE	LLN
13	LOCATE/DEFLECTION	LDF
14	INVERSE/AZIMUTH	IAZ
15	INVERSE/BEARING	IBR
16	PARALLEL/LINE	PLN
17	TANGENT/OFFSET	TOF
18	RT/TRI/HYP	RTH
19	RT/TRI/LEG	RTL
20	ANGLE	ANG
21	ARC/POINT	ARC
22	POINTS/INTERSECT	PIN
23	AZ/INTERSECT	AIN
24	BR/INTERSECT	BIN
25	DIVIDE/LINE	DLE
26	ARC/LINE/POINTS	ALP
27	ARC/ARC/INTERSECT	AA
28	ARC/LINE/AZ	ALA
29	ARC/LINE/BR	ALB
30	DIVIDE/ARC	DAE
31	SEGMENT	SEG
32	SEGMENT/PLUS	SPL
33	SEGMENT/MINUS	SMI
34	TANGENT	TAN
35	SIMPLE/CURVE	SC
36	DEFINE/CURVE	DC
37	ALIGNMENT	ALN
38	COORD/POA	CPA
39	COORD/OFFSET	COF
40	OFFSET/ALIGN	OFA
41	STATION/FROM/COORD	SFC
42	SIMPLE/SPIRAL	S/S
43	SPIRAL/LENGTH	S/L
44	SPIRAL/OFFSET	S/O
45	COORD/POSP	COP
46	LINE/SPIRAL	L/S
47	COMPOUND/SPIRAL	C/S
48	SPIRAL/SPIRAL	SS
49	CURVE/SPIRAL	CS
50	FIT/ALIGNMENT	FA

51	AREA	AR
52	AREA/AZIMUTHS	ARA
53	AREA/BEARINGS	ARB
54	AREA/STORI	AST
55	MULTIPLY/AREA	MUA
56	TOTAL/AREA	TOA
57	LOTS/COMP	LOT
58	DIVIDE/AREA	DA
59	ADJUST/DEFLECTION/LS	ADS
60	ADJUST/AZIMUTH/LS	AAS
61	ADJUST/BEARING/LS	ABS
62	VERTICAL/START	VS
63	VERTICAL/END	VE
64	EVEN/STATIONS	ES
65	OFFSET/ELEV	OE
66	CURVE/DRAIN	CD
67	SLOPE/LENGTH	SL
68	SCALE	SCL
69	PLOT	PLT
70	PLOT/LINES	PLL
71	PLOT/CURVE	PLC
72	PLOT/ALIGNMENT	PLA
73	PLOT/POINTS	PLP
74	PLOT/DASHL	PDL
75	SCALE	SCL
76	PLOT/SPIRAL	PLS
77	PLOT/DESCRIPTION	PTD
78	PLOT/SYMBOL	PTS
79	STOP/PLOT	STP
80	OPEN/FILE	OPF
81	CLOSE/FILE	CLF
82	READ/FILE	REF
83	WRITE/FILE	WRF
84	RT/TRI/PT	RTP

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